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On the Earth Microwave Background: Absorption and Scattering by the Atmosphere

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The absorption and scattering of microwave radiation by the atmosphere of the Earth is considered under a steady state scenario. Using this approach, it is demonstrated that the microwave background could not have a cosmological origin. Scientific observations in the microwave region are explained by considering an oceanic source, combined with both Rayleigh and Mie scattering in the atmosphere in the absence of net absorption. Importantly, at high frequencies, Mie scattering occurs primarily with forward propagation. This helps to explain the lack of high frequency microwave background signals when radio antennae are positioned on the Earth's surface.

1 Introduction

The absorption of radiation by the atmosphere of the Earth has been highly studied and exploited [1–3]. In the visible region, atmospheric absorption accounts for significant deviations of the solar spectrum from the thermal lineshape. These deviations are removed when viewing the spectrum from the outer atmosphere. Under these conditions, the solar spectrum now differs from the ideal lineshape only slightly. The remaining anomalies reflect processes associated with the photosphere itself.

In the microwave region, absorption of radiation is primarily associated with reversible quantum transitions in the vibrational-rotational states of gaseous molecules, particularly oxygen and water. Intense absorption occurs in several bands. The high frequency microwave bands are consequently less suited for signal transmission to, or from, satellites [1].

2 The Microwave Background

The microwave background [4] is currently believed to be of cosmic origin. The Earth is viewed as immersed in a bath of signal arising continuously from every possible direction, without directional preference. This is an intriguing physical problem in that it represents a steady state condition, not previously considered relative to atmospheric absorption. Indeed, all other atmospheric absorption problems involve sources which are temporally and spatially dependent. Such sources are radically different from the steady state.

Since the microwave background is temporally continuous and spatially isotropic, and since the vibrational-rotational transitions of gases are reversible, the steady state scenario leads to the absence of net absorption of microwave radiation in the atmosphere. An individual absorbing species, such as molecular oxygen or water, acts simply as a scatterer of radiation. Any radiation initially absorbed will eventually be re-emitted. There can be no net absorption over time. Only the effects of direct transmission and/or scattering can exist. Herein lies the problem for assigning the microwave background to a cosmic origin. The steady state results in a lack of net absorption by the atmosphere. Thus, if the signal was indeed of cosmic origin, there could be no means for the atmosphere to provide signal attenuation at high frequency. Assuming frequency independent scattering, a perfect thermal spectrum should have been received, even on Earth. Nonetheless, the high frequency components of the microwave background, on the ground, are seriously attenuated. Only at the position of the COBE satellite has a nearly perfect thermal spectrum been recorded [5].

3 Oceanic origin of the Microwave Background

It has previously been advanced that the microwave background is of oceanic origin [6–8]. Under this hypothesis, the oceans of the Earth are emitting a signal which mimics a blackbody source. This radiation is being emitted over all possible angles. The path length that radiation travels through the atmosphere can therefore be quite substantial, especially at the lower emission angles. Arguably, this oceanic signal, with its 2.7 K apparent temperature, indirectly reflects the presence of translational and rotational degrees of freedom in the liquid. The weak hydrogen bonds between water molecules, and their associated vibrational degrees of freedom, are likely to be the underlying physical oscillators fundamentally responsible for this spectrum.

At low frequencies, oceanic radiation travels into the atmosphere where Rayleigh scattering may occur. This results in a substantial fraction of backscattering, since Rayleigh scattering is multidirectional. Consequently, the low frequency signals can easily be detected on Earth. However, at high microwave frequencies, Mie scattering dominates increasingly. Mie scattering, at the elevated frequencies, results primarily in forward propagation of the incident signal. The presence of forward scattering accounts for the lack of high frequency signals detected for the microwave background on

Earth. Forward scattering produces a preferential directionality away from the surface of the Earth. The variation of atmosperic density with elevation may also contribute to this observation. As a result, the high frequency portion of the microwave background is not well detected from the Earth. Since the problem is once again in the steady state regimen, there can be no net absorption in the atmosphere. Given sufficient scattering at all frequencies, at the position of COBE [5], the signal examined must be isotropic. At elevated frequencies, perfect scattering of the oceanic signals is being ensured by the absorption and re-emission of radiation by atmospheric gases. These processes follow substantial forward scattering. Of course, Rayleigh scattering is also being produced by small matter and scatterers in the lower atmosphere, particularly for the lower frequencies.

4 Conclusion

Given steady state, there can be no net absorption of microwave signals by the atmosphere. Yet, on Earth, the microwave background cannot be properly detected in the high frequency region. This directly implies that the microwave background cannot arise from the cosmos. Conversely, if one considers that the signal is oceanic in nature, the observed behavior of the microwave background on Earth is easily explained using a combination of absorption, re-emission, Rayleigh and Mie scattering, wherein forward propagation is also invoked. An oceanic signal followed by scattering also helps to explain the phenomenal signal to noise observed by the COBE FIRAS instrument [5]. Powerful signals imply proximal sources. This constitutes further evidence that the microwave background [4] is of Earthly origin [6–8]. We will never know the temperature of the Universe.

Dedication

This work is dedicated to Patricia Anne Robitaille.

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Phase-Variation Enhancement on Deuteron Elastic Scattering from Nuclei at Intermediate Energies

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Within the modified formalism of Glauber's multiple scattering theory, we have studied the elastic scattering of deuteron with nuclei in the mass region $6 \leqslant B \leqslant 72$ at intermediate energies. We have calculated the differential cross-section with and without invoking the phase-variation parameter into the nucleon-nucleon (NN) scattering amplitude and compared our results with the corresponding experimental data. We found that the presence of the phase-variation improves our results, especially at the minima of the diffraction patterns.

1 Introduction

In the interaction of a light ion with nuclei, elastic scattering is the largest of all partial cross sections. For projectile energies sufficiently above the Coulomb barrier, the elastic angular distribution is dominated by a diffractionlike pattern. It was realized [1] that this phenomenon is due to the finite size of the nucleus and the fact that nuclei are ”partially trnsparent”. One of the most important approaches used to describe such collisions is the Glauber's multiple scattering theory (GMST) [2–4]. The theory is based on high-energy approximation, in which the interacting particles are almost frozen in their instantaneous positions during the passage of the projectile through the target. As a result, the nucleon-nucleus and nucleus-nucleus scattering amplitudes are simply expressed in terms of the free nucleon-nucleon (NN) ones. The preliminary applications of this theory were found to have great successes in reproducing the hadron-nucleus scattering data [5–13]. The confidence in this theory encouraged the extension of its application to nucleus-nucleus collisions but this was faced with computational difficulties [14–19] for collisions between two nuclei of mass numbers A, $B \geqslant 4$. The series describing these collisions contains numerous $(2^{A\times B}-1)$ terms so that its complete summation is extensive. Moreover, the higher order multiple scatterings involve multi-dimensional integrals, which are cumbersome to be evaluated, even if one uses simple Gaussian forms for the nuclear densities and NN scattering amplitudes. These drawbacks were overcomed in the works of many authors like Yin et al. [20, 21], Franco and Tekou [14], Huang [22] and El-Gogary et al. [23–25]. Their results describe more satisfactorily the scattering data for the elastic collisions considered there except smaller shifts were found to exist around the diffraction patterns.

Our previous works dealt with studies the elastic scattering of hadrons either with stable nuclei [26, 27] or exotic nuclei [28]. The results are found to be good except around the diffraction pattern (as the previous authors showed) where overall shifts are still persists. It is of special interest to probe the validity of the Glauber multiple scattering theory for the elastic scattering of deuterons (which are weakly bound composite particles) with nuclei.

The essential feature of the presently proposed method is the use of a phase variation of the nucleon-nucleon elastic scattering amplitude which agrees with the empirical amplitude at low q's at the appropriate energy and its large-q behaviour is left adjustable in terms of one free parameter. The effect of the phase variation is to eliminate minima or to make them shallower and to generally increase cross-sections even at the momentum transfers where no minima originally occurred [29, 30]. Franco and Yin [31, 32] have suggested that the phase of the NN scattering amplitude should vary with the momentum transfer. So far the physical origin of this phase variation has not been settled. This phase modifies the ratio of the real part to the imaginary part of the forward amplitude and makes the diffraction pattern shallower.

Our present work is directed toward two ways; first, we have studied the elastic scattering of deuteron with nuclei in the mass region $6 \leqslant B \leqslant 72$ using the GMST where both the full multiple scattering series of the Glauber amplitude and the consistent treatment of the center-of-mass (c.m.) correlations are simultaneously employed. Second, as a result of the shifts appeared around the diffraction patterns in the previous works mentioned above, it is helpful to study the role of the phase-variation parameter of the NN scattering amplitude as invoked in this work. The theoretical formulas used to do the above calculations are given in Section 2. Section 3 includes the results and their discussions. The conclusion is summarized in Section 4. The orbits, lengths and Δ-matrices required for carrying out the above calculations are exhibited in the appendix.

2 Theoretical framework

This section is devoted to obtain the expression for the angular distribution ($\frac{d\sigma}{d\Omega}$ or $\frac{\sigma}{\sigma_{RUTH}}$) for the elastic scattering of deuteron with medium-weighted nuclei using Glauber's multiple scattering theory. This expression is developed by taking into account both the full series expansion of the Glauber amplitude and the consistent treatment of the center-of-mass correlation.

In this theory, the elastic scattering amplitude between deuteron of mass number A and a target nucleus of mass number B and atomic number Z_B is given as [16]

$$F_{dB}(\vec{q}) = \frac{ik}{2\pi}\,\Theta(\vec{q})\int d\vec{b}\exp(i\vec{q}\cdot\vec{b})\Big\{1-\exp\big(i\chi_{dB}(\vec{b})\big)\Big\} \quad (1)$$

where, $\vec{q}$ is the momentum transferred from the deuteron to the target nucleus B, $\vec{k}$ is the incident momentum of the deuteron, and $\vec{b}$ is the impact parameter vector. $\Theta(\vec{q})$ arising from the effect of the center-of-mass correlations [16] and it was found to has an exponential form of q-squared [17]. $\chi_{dB}(\vec{b})$ is the nuclear phase-shift function resulting from the interaction between the deuteron and a target nucleus B and it is given by,

$$\begin{aligned}\exp\big[i\chi_{dB}(\vec{b})\big] &= <\Psi_d(\{\vec{r}_i'\})\,\Psi_B(\{\vec{r}_j'\}) \\ &\big|\exp\big[i\chi_{dB}(\vec{b},\{\vec{s}_i'\},\{\vec{s}_j'\})\big]\big|\,\Psi_d\Psi_B>,\end{aligned} \quad (2)$$

where, $\Psi_d(\{\vec{r}_i'\})\lfloor\Psi_B(\{\vec{r}_j'\})\rfloor$ is the deuteron (target) wave functions that depends on the position vectors $\{\vec{r}_i\}\lfloor\{\vec{r}_j'\}\rfloor$ of the deuteron (target) nucleons whose projections on the impact parameter plane are $\{\vec{s}_i\}\lfloor\{\vec{s}_j'\}\rfloor$.

In Eq. (1), the effect of the center-of-mass correlation is treated as a global correction (denoted by $\Theta(\vec{q})$) multiplied by the scattering amplitude. Because $\Theta(\vec{q})$ leads to unphysical divergence as q goes to high values, Franco and Tekou [14] have overcomed this drawback by incorporating it in each order of the optical phase-shift expansion. Such treatment has modified the phase-shift function to a new form, which is simply expressed in terms of the uncorrelated one.

Thus, Eq. (1) becomes

$$F_{dB}(\vec{q}) = \frac{ik}{2\pi}\int d\vec{b}\exp(i\vec{q}\cdot\vec{b})\Big\{1-\exp\big(i\bar{\chi}_{dB}(\vec{b})\big)\Big\}, \quad (3)$$

where the modified phase-shift function $\bar{\chi}_{dB}(\vec{b})$ (which is referred here by adding a bar sign on the corresponding uncorrelated one) can be written in terms of the uncorrelated one, $\chi_{dB}(\vec{b})$, as [16, 17]

$$\begin{aligned}&\exp\big[i\bar{\chi}_{dB}(\vec{b})\big] = \\ &=\int_0^\infty J_0(qb)\Theta(q)q\,dq\int_0^\infty J_0(qb')\exp\big[i\bar{\chi}_{dB}(\vec{b}')\big]b'db',\end{aligned} \quad (4)$$

By taking into account the Coulomb phase-shift function in addition to the nuclear one, we can write

$$\begin{aligned}\bar{\chi}_{dB}(\vec{b}) &= \bar{\chi}_n(\vec{b}) + \bar{\chi}_C(\vec{b}) = \\ &= \bar{\chi}_n(\vec{b}) + \bar{\chi}_C^{pt}(\vec{b}) + \bar{\chi}_C^{E}(\vec{b}),\end{aligned} \quad (5)$$

where $\bar{\chi}_C^{pt}(\vec{b})$ is the modified point charge correction to the Coulomb phase-shift function, which is equal to $2n\ln\left(\frac{b}{2a}\right)$, a is equal to $\frac{1}{2k}$, $n = \frac{Z_B e^2}{\hbar v}$ is the usual Coulomb parameter and $\bar{\chi}_C^{E}(\vec{b})$ is the modified extended charge correction to the Coulomb phase shift function. $\bar{\chi}_n(\vec{b})$ is the modified nuclear interaction phase-shift function.

From Eqs. (3) and (5), we find [16, 25]

$$\begin{aligned}F_{dB}(\vec{q}) &= f_C^{pt}(q) + i\int_0^\infty (kb)^{2in+1}\times \\ &\times\Big\{1-\exp\big(i\bar{\chi}_C^{E}(\vec{b})+i\bar{\chi}_n(\vec{b})\big)\Big\}J_0(qb)db\,.\end{aligned} \quad (6)$$

Assuming the projectile (deuteron) and target ground state wave functions to have the form:

$$\Psi_{i=d,B}(\{\vec{r}_j\}) = \xi_i(\vec{R}_i)\,\Phi_i(\{\vec{r}_j^{\,int}\}),\ \vec{r}_j^{\,int} = \vec{r}_j - \vec{R}_i, \quad (7)$$

where $\xi_i(\vec{R}_i)$, where $i=d,B$, are the wave functions describing the center-of- mass motions of the deuteron and target nucleons, respectively. Accordingly, the center-of-mass correlation function $\Theta(\vec{q})$ is found to has the form

$$\Theta(\vec{q}) = \Big[<\xi_d(\vec{R}_d)\,\xi_B(\vec{R}_B)\,|\,e^{i\vec{q}(\vec{R}_d-\vec{R}_B)}|\,\xi_d\xi_B>\Big]^{-1}, \quad (8)$$

Now, we need to describe the wave function of the system to perform the integrations of Eqs. (2) and (8). Consider the approximation in which the nucleons inside any cluster and the clusters themselves inside the nucleus are completely uncorrelated. Then, we can write

$$|\Psi_d\Psi_B|^2 = \Pi_{i=1}^{M_A}\,\Pi_{\alpha=1}^{M_N}\,\rho_d(\vec{r}_{i\alpha})\,\Pi_{j=1}^{M_B}\,\Pi_{\delta=1}^{M_N}\,\rho_B(\vec{r}_{j\delta}'), \quad (9)$$

where ρ_d and ρ_B are the normalized single particle density functions and are chosen in the present work to be of the single-Gaussian density which is given as [25, 26, 28]

$$\rho_\gamma(\vec{r}) = \left(\frac{\alpha_\gamma^2}{\pi}\right)^{3/2}\exp(-\alpha_\gamma^2 r^2), \quad \gamma = d, B, \quad (10)$$

where α_γ is related to the rms radius by

$$\alpha_\gamma = \sqrt{\frac{3}{2}}\left(\frac{1}{<r_\gamma^2>^{1/2}}\right).$$

With the aid of the NN scattering amplitude, $f_{NN}(\vec{q})$, which is given as [22, 32]

$$f_{NN}(\vec{q}) = \frac{k_N\sigma}{4\pi}(i+\rho)\exp\left(\frac{-aq^2}{2}\right), \quad (11)$$

where, k_N is the momentum of the incident particle, σ, is the total cross-section and ρ is the ratio of the real to the imaginary parts of the forward scattering amplitude. a is taken to be complex; $a=\beta^2+i\gamma^2$, where β^2 is the slope parameter of the elastic scattering differential cross-section, and γ^2 is a free parameter introducing a phase variation of the elemental scattering amplitude, adopting the wave function (9) with the density (10) and following the same procedures as that given in Ref. [25], we can perform the integrations in Eqs. (8) and (2) analytically and get

$$\Theta_s(q) = \exp\left[\frac{q^2}{4}\left(\frac{1}{A\alpha_d^2} + \frac{1}{B\alpha_B^2}\right)\right] \tag{12}$$

and

$$\begin{aligned} \exp\big[i\chi_n(b)\big] &= 1 + \sum_{\mu_1=1}^{M_1}\sum_{\lambda_{\mu_1}} T_1(\mu_1, \lambda_{\mu_1}) \times \\ &\quad \times \Pi_{i=1}^{M_A}\Pi_{j=1} M_B\{Z_S\}^{\Delta_{ij}(\mu_1,\lambda_{\mu_1})}, \end{aligned} \tag{13}$$

where Z_S has the reduced form

$$\begin{aligned} Z_S &= C_{dB}\sum_{\mu_2=1}^{M_2}\sum_{\lambda_{\mu_2}} T_2(\mu_2, \lambda_{\mu 2})[-g]^{\mu_2} \times \\ &\times R_S[\mu_2, \lambda_{\mu 2}, \Delta(\mu_2, \lambda_{\mu 2}), 0, 0, \ldots] \times \\ &\times \left(\exp\{-W_S[\mu_2, \lambda_{\mu 2}, \Delta(\mu_2, \lambda_{\mu 2}), 0, 0, \ldots]\, b^2\}\right), \end{aligned}$$

with

$$C_{dB} = \left[\frac{\alpha_d^2\,\alpha_B^2}{\pi^2}\right]^{M_N}$$

The various functions (Θ, Z, R and W) are marked by the subscript s to refer to the employed single-Gaussian density. Incorporating the c.m. correlation, the modified phase-shift function $\bar{\chi}_n(\vec{b})$ can be expressed as

$$\begin{aligned} \exp\big[i\bar{\chi}_n(b)\big] &= 1 + \sum_{\mu_1=1}^{M_1}\sum_{\lambda_{\mu_1}} T_1(\mu_1, \lambda_{\mu_1}) \times \\ &\quad \times \Pi_{i=1}^{M_A}\Pi_{j=1}^{M_B}\{\bar{Z}_S\}^{\Delta_{ij}(\mu_1,\lambda_{\mu_1})}, \end{aligned} \tag{14}$$

The form of $\bar{Z}_S$ is obtained by inserting the expressions of Z_S and $\Theta_S(\vec{q})$ into Eq. (4), yielding

$$\begin{aligned} \bar{Z}_S &= C_{dB}\sum_{\mu_2=1}^{M_2}\sum_{\lambda_{\mu_2}} T_2(\mu_2, \lambda_{\mu 2})[-g]^{\mu_2} \times \\ &\times \bar{R}_S[\mu_2, \lambda_{\mu 2}, \Delta(\mu_2, \lambda_{\mu 2}), 0, 0, \ldots] \times \\ &\times \left(\exp\{-\bar{W}_S[\mu_2, \lambda_{\mu 2}, \Delta(\mu_2, \lambda_{\mu 2}), 0, 0, \ldots]\, b^2\}\right), \end{aligned} \tag{15}$$

with

$$\bar{W}_s = \left[\frac{1}{W_s} - \left(\frac{1}{A\alpha_d^2} + \frac{1}{B\alpha_B^2}\right)\right]^{-1} \text{ and } \bar{R}_s = \frac{R_s \times \bar{W}_s}{W_s}$$

Finally, the modified extended charge correction to the Coulomb phase — shift, $\bar{\chi}_C^E(b)$, has already been derived analytically in Ref. [16] for a single-Gaussian density where it was found to have the form

$$\bar{\chi}_C^E(b) = nE_1(b^2/\bar{R}^2) \tag{16}$$

where $E_1(z)$ is the exponential integral function and,

$$\bar{R}^2 = R_d^2(1-A^{-1}) + R_B^2(1-B^{-1}),\ R_d^2 = \frac{1}{\alpha_d^2},\ R_B^2 = \frac{1}{\alpha_B^2}.$$

With the results of Eqs. (14), (15) and (16), the scattering amplitude $F_{dB}(q)$ can be obtained by performing the integration in Eq. (6) numerically. Whence, the angular distribution of the elastic scattering is given by

E/A (MeV/nucleon)	σ_{NN} (fm^2)	ρ_{NN}	β^2 (fm^2)
25	24.1	0.85	0.8258599
40	13.5	0.9	0.4861189
60	9.15	1.1725	0.3755747
85	6.1	1.0	0.2427113
342.5	2.84	0.26	0.045

Table 1: Parameters of the Nucleon-Nucleon amplitude [34, 35].

$$\frac{d\sigma(q)}{d\Omega} = \left|F_{dB}(q)\right|^2. \tag{17}$$

The point change approximation of the coulomb amplitude $f_c^{pt}(\vec{q})$, is given as [33]

$$\begin{aligned} f_c^{pt}(q) &= -2nkq^{-2} \times \\ &\times \exp\big\{-i\big[2n\ln(qa) - 2\arg\Gamma(1+in)\big]\big\}. \end{aligned} \tag{18}$$

The Rutherford formula for the differential cross section, σ_{RUTH} is then given by

$$\sigma_{RUTH} = |f_c^{pt}(q)|^2 = 4n^2k^2q^{-4}, \tag{19}$$

where a, n, k, q have the same definitions that given above.

3 Results and discussion

To examine the simple analysis presented in the above section, we have calculated the differential cross section for a set of elastic nuclear reactions, like, d-$_3$Li^6, d-$_8$O^{16}, d-$_{23}$V^{50}, d-$_{32}$Ge^{70} and d-$_{32}$Ge^{72} at incident energies 171 MeV, d-$_6$C^{12} at 110, 120 and 170 MeV, d-$_{16}$S^{32} at 52 and 171 MeV, d-$_{20}$Ca^{40} at 52 and 700 MeV, d-$_{28}$Ni^{58} at 80, 120 and 170 MeV and d-$_{12}$Mg^{24} at 170MeV. The ingredients needed to perform these calculations are the parameters associated with the NN scattering amplitude and the nuclear densities as well as the orbits, lengths and Δ-matrices of the groups $G_1 = S_{M_A} \otimes S_{M_B}$ and $G_2 = S_{M_N} \otimes S_{M_N}$. For the above energies, we used the values of the NN parameters given in Table 1.

The values of the parameters α_γ, after correcting for the effects of the finite proton-size and the c.m. recoil, are [16]

$$\alpha_\gamma^2 = \frac{3}{2}\left(\frac{1-\frac{1}{\gamma}}{<r_\gamma^2> - <r_p^2>}\right), \qquad \gamma = A, B,$$

where $<r_\gamma^2>$ and $<r_p^2>$ are the mean square radii of the deuteron, target nucleus and the proton, respectively. The values of the rms radii we have used for the present nuclei and the proton are given in Table 2.

The cluster structure specific to the considered reactions and the corresponding orbits, lengths and Δ-matrices are exhibited in Appendix.

The results obtained from these calculations for the considered reactions are shown as dashed curves in Figs. 1–16. Fig. 1 contains the result obtained for d-$_3$Li^6 reaction at incident energy 171 MeV. We can see from this figure that the predicted angular distribution satisfactorily agree the scatter-

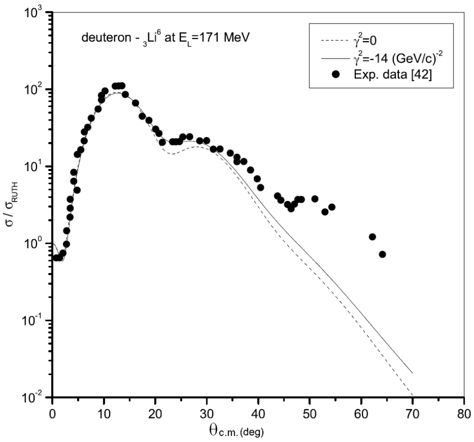

Fig. 1: Plots the elastic differential cross section (σ/σ_{RUTH}) versus scattering angle for the deuteron-$_3Li^6$ reaction at incident energy 171 MeV. The dashed curve is the constant phase result ($\gamma^2 = 0$) while the solid curve is obtained with phase variation ($\gamma^2 = -14$ (GeV/c)$^{-2}$). The dots are the experimental data [42].

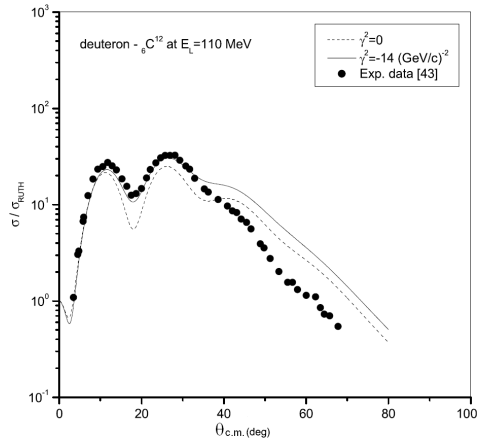

Fig. 2: Plots the elastic differential cross section (σ/σ_{RUTH}) versus scattering angle for the deuteron-$_6C^{12}$ reaction at incident energy 110 MeV. The dashed curve is the constant phase result ($\gamma^2 = 0$) while the solid curve is obtained with phase variation ($\gamma^2 = -14$ (GeV/c)$^{-2}$). The dots are the experimental data [43].

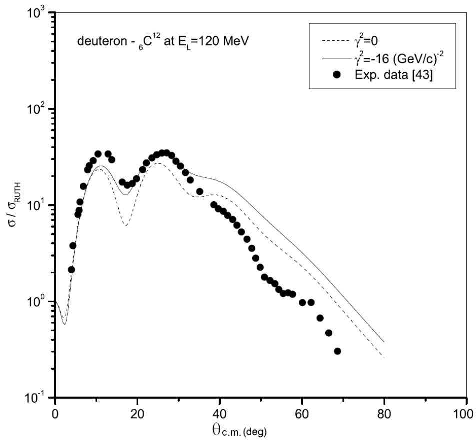

Fig. 3: Plots the elastic differential cross section (σ/σ_{RUTH}) versus scattering angle for the deuteron-$_6C^{12}$ reaction at incident energy 120 MeV. The dashed curve is the constant phase result ($\gamma^2 = 0$) while the solid curve is obtained with phase variation ($\gamma^2 = -16$ (GeV/c)$^{-2}$). The dots are the experimental data [43].

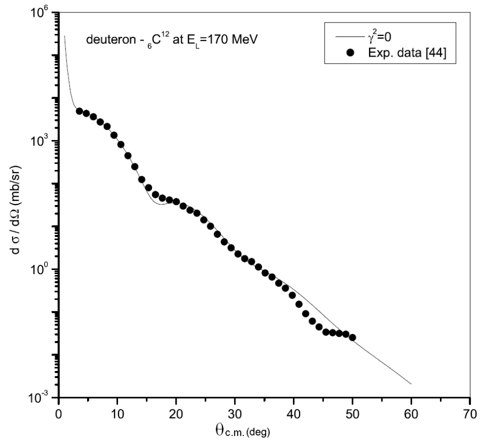

Fig. 4: Plots the elastic differential cross section ($d\sigma/d\Omega$) versus scattering angle for the deuteron-$_6C^{12}$ reaction at incident energy 170 MeV. The solid curve is the constant phase result ($\gamma^2 = 0$). The dots are the experimental data [44].

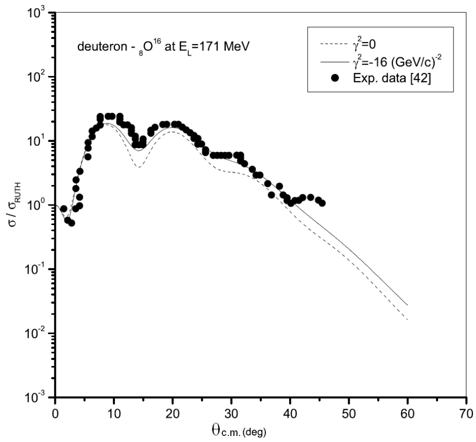

Fig. 5: Plots the elastic differential cross section (σ/σ_{RUTH}) versus scattering angle for the deuteron-$_8O^{16}$ reaction at incident energy 171 MeV. The dashed curve is the constant phase result ($\gamma^2 = 0$) while the solid curve is obtained with phase variation ($\gamma^2 = -16$ (GeV/c)$^{-2}$). The dots are the experimental data [42].

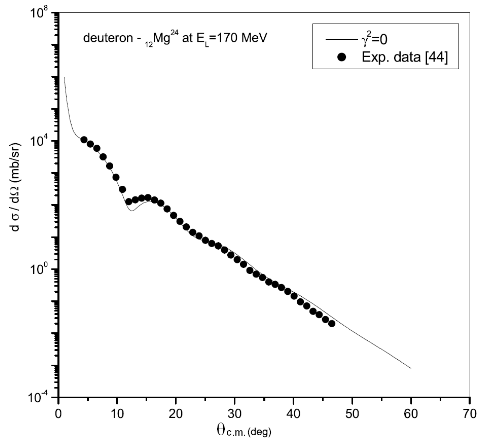

Fig. 6: Plots the elastic differential cross section ($d\sigma/d\Omega$) versus scattering angle for the deuteron-$_{12}Mg^{24}$ reaction at incident energy 170 MeV. The solid curve is the constant phase result ($\gamma^2 = 0$). The dots are the experimental data [44].

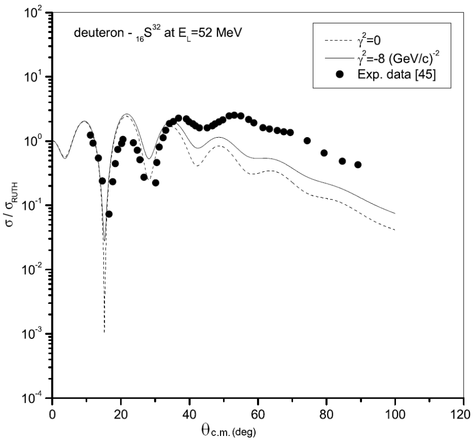

Fig. 7: Plots the elastic differential cross section (σ/σ_{RUTH}) versus scattering angle for the deuteron-$_{16}S^{32}$ reaction at incident energy 52 MeV. The dashed curve is the constant phase result ($\gamma^2 = 0$) while the solid curve is obtained with phase variation ($\gamma^2 = -8$ (GeV/c)$^{-2}$). The dots are the experimental data [45]

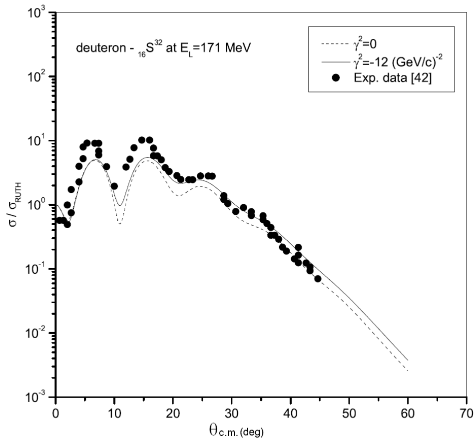

Fig. 8: Plots the elastic differential cross section (σ/σ_{RUTH}) versus scattering angle for the deuteron-$_{16}S^{32}$ reaction at incident energy 171 MeV. The dashed curve is the constant phase result ($\gamma^2 = 0$) while the solid curve is obtained with phase variation ($\gamma^2 = -12$ (GeV/c)$^{-2}$). The dots are the experimental data [42].

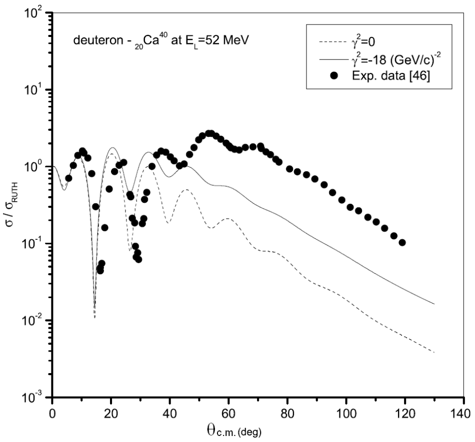

Fig. 9: Plots the elastic differential cross section (σ/σ_{RUTH}) versus scattering angle for the deuteron- $_{20}Ca^{40}$ reaction at incident energy 52 MeV. The dashed curve is the constant phase result ($\gamma^2 = 0$) while the solid curve is obtained with phase variation ($\gamma^2 = -18$ (GeV/c)$^{-2}$). The dots are the experimental data [46].

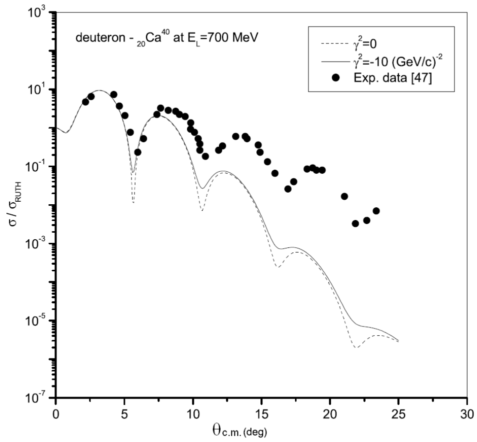

Fig. 10: Plots the elastic differential cross section (σ/σ_{RUTH}) versus scattering angle for the deuteron-$_{20}Ca^{40}$ reaction at incident energy 700 MeV. The dashed curve is the constant phase result ($\gamma^2 = 0$) while the solid curve is obtained with phase variation ($\gamma^2 = -10$ (GeV/c)$^{-2}$). The dots are the experimental data [47].

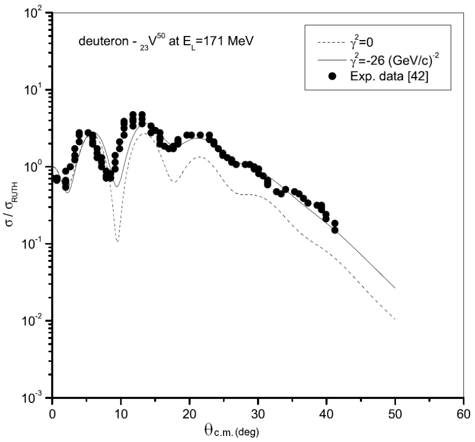

Fig. 11: Plots the elastic differential cross section (σ/σ_{RUTH}) versus scattering angle for the deuteron-$_{23}V^{50}$ reaction at incident energy 171 MeV. The dashed curve is the constant phase result ($\gamma^2 = 0$) while the solid curve is obtained with phase variation ($\gamma^2 = -26$ (GeV/c)$^{-2}$). The dots are the experimental data [42].

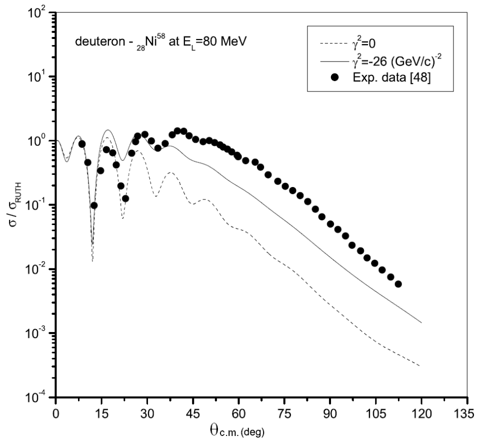

Fig. 12: Plots the elastic differential cross section (σ/σ_{RUTH}) versus scattering angle for the deuteron-$_{28}Ni^{58}$ reaction at incident energy 80 MeV. The dashed curve is the constant phase result ($\gamma^2 = 0$) while the solid curve is obtained with phase variation ($\gamma^2 = -26$ (GeV/c)$^{-2}$). The dots are the experimental data [48].

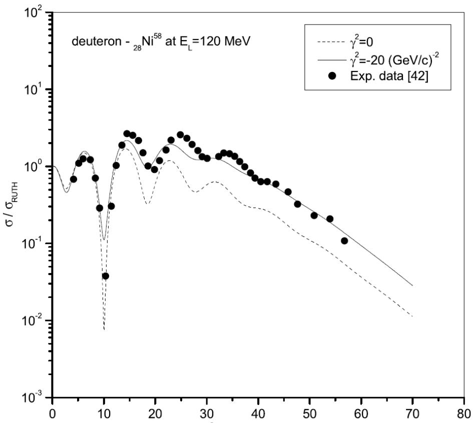

Fig. 13: Plots the elastic differential cross section (σ/σ_{RUTH}) versus scattering angle for the deuteron-$_{28}Ni^{58}$ reaction at incident energy 120 MeV. The dashed curve is the constant phase result ($\gamma^2 = 0$) while the solid curve is obtained with phase variation ($\gamma^2 = -20$ (GeV/c)$^{-2}$). The dots are the experimental data [42].

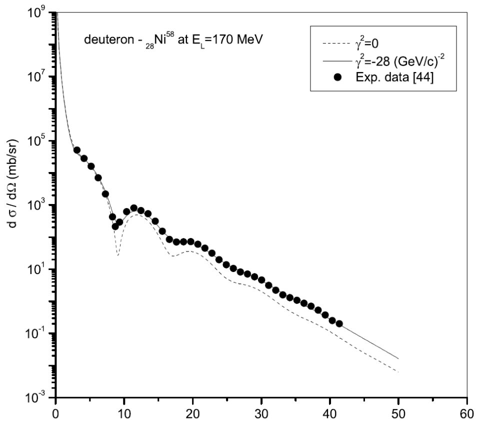

Fig. 14: Plots the elastic differential cross section ($d\sigma/d\Omega$) versus scattering angle for the deuteron-$_{28}Ni^{58}$ reaction at incident energy 170 MeV. The dashed curve is the constant phase result ($\gamma^2 = 0$) while the solid curve is obtained with phase variation ($\gamma^2 = -28$ (GeV/c)$^{-2}$). The dots are the experimental data [44].

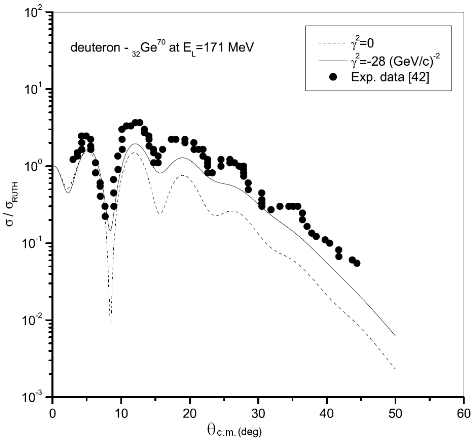

Fig. 15: Plots the elastic differential cross section (σ/σ_{RUTH}) versus scattering angle for the deuteron-$_{32}Ge^{70}$ reaction at incident energy 171 MeV. The dashed curve is the constant phase result ($\gamma^2 = 0$) while the solid curve is obtained with phase variation ($\gamma^2 = -28$ (GeV/c)$^{-2}$). The dots are the experimental data [42].

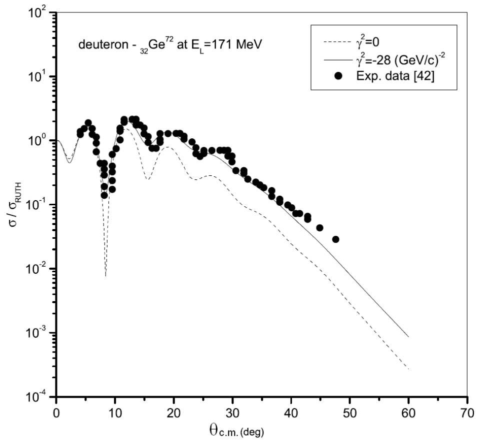

Fig. 16: Plots the elastic differential cross section (σ/σ_{RUTH}) versus scattering angle for the deuteron-$_{32}Ge^{72}$ reaction at incident energy 171 MeV. The dashed curve is the constant phase result ($\gamma^2 = 0$) while the solid curve is obtained with phase variation ($\gamma^2 = -28$ (GeV/c)$^{-2}$). The dots are the experimental data [42].

Nucleus	P	d	Li^6	C^{12}	O^{16}	Mg^{24}
$\sqrt{<r^2>}$ (fm)	0.810	2.170	2.450	2.453	2.710	2.980
Ref.	16	16	36	16	16	16
Nucleus	S^{32}	Ca^{40}	V^{50}	Ni^{58}	Ge^{70}	Ge^{72}
$\sqrt{<r^2>}$ (fm)	3.239	3.486	3.615	3.790	4.070	4.050
Ref.	37	16	37	16	37	37

Table 2: Nuclear rms radii.

ing data except a smaller shift is found at the minimum. The predicted angular distribution for d-$_6C^{12}$ elastic collision at the energies 110, 120 and 170 MeV is shown in Figs. 2–4 respectively. The scattering data is well reproduced in the last case (at 170 MeV) rather than in the other two cases (110 and 120 MeV) where smaller shifts are still appeared around the diffraction patterns. For d-$_8O^{16}$ reaction, Fig. 5, the predicted angular distribution is in good agreement with the corresponding experimental data. In Fig. 6 we presented the case of the d-$_{12}Mg^{24}$ reaction at bombarding energy 170 MeV. One can easily see from this figure that the predicted angular distribution give an excellent account to the experimental data over the whole range of the scattering angles. The calculated angular distribution for the d-$_{16}S^{32}$ reaction at energies 52 and 171 MeV are shown in Figs. 7–8. We observe from these figures that the predicted angular distribution for the 171 MeV is much better in reproducing the scattering data than that obtained at 52 MeV and smaller shifts are found around the minima in both of them. The results for the angular distribution of the elastic scattering of 52 and 700 MeV deuteron on $_{20}Ca^{40}$ nuclei are shown in Figs. 9–10. The calculations reproduce reasonably the scattering data up to the angular range ($\theta \leqslant 35^\circ$) for the first reaction and up to ($\theta \leqslant 10^\circ$) for the second reaction, while for larger angles just the qualitative trend is accounted for. For d-$_{23}V^{50}$ reaction, Fig. 11, the data are reasonably reproduced with a smaller shift away from the forward angles. Enlarging the mass of the target nucleus as in the d-$_{28}Ni^{58}$ reaction, Figs. 12–14, one can easily see that the predicted angular distribution in the later case are twofold better in reproducing the experimental data than in the others with smaller shifts still found in all of them. For Germanium target nuclei as in the case of d-$_{32}Ge^{70}$ and d-$_{32}Ge^{72}$ reactions, Figs. 15–16, the data are quantitatively represented at the forward angles and qualitatively reproduced at the backward angles.

On discussing these results, the positive picture obtained at smaller values of momentum transfer is expected because the Glauber theory is a very good approximation at forward angles. But at larger angles poorer fits are obtained as the energy increases was not expected.

However, we should keep in mind that at these energies the input NN cross sections parameters are strongly dependent on energy as shown in Table 1. Therefore, the scattering would be very sensitive to the large q-details of the density distributions and the elemental scattering amplitudes.

In the vie of the analysis made by several authors [30, 38–41], the question about the influence of invoking a phase-variation in the NN scattering amplitude is investigated in our calculations. To investigate how the q-dependent phase $\exp\frac{-i\gamma^2 q^2}{2}$ affects the deuteron-nucleus elastic scattering, we have carried out extensive numerical calculations for most of our considered reactions (where smaller shifts are found around their diffraction patterns), at various nonzero values of the phase parameter γ^2. The calculations showed that for a given value of the ratio parameter ρ, the variation of γ^2 leads to either overall increase or decrease in the estimated values of the cross sections. Indeed, we found that such change in the cross section takes place depending on the signs of ρ and γ^2, i.e. if ρ is positive, the negative value of γ^2 increases the cross section while the positive value decreases it and vice versa. Hence, a nonzero value for ρ implies a single nonzero value for γ^2 as well. This in fact agrees with what was predicted before by Ahmad and Alvi [39] from potential model calculation. However, the best results of the present calculations are shown by the solid curves in our figures. On comparing the solid curve (at $\gamma^2 \neq 0$) with the dashed curve (at $\gamma^2 = 0$) in each figure, we can note that the influence of the phase is obvious only at the minima and is roughly notable at the momentum transfers where no minima originally occurred. In general, taking this phase into account gives better agreement with the scattering data, Figs. 5, 11, 13, 14 and 16, while the improvement is confined at the minima of the results obtained for the other reactions presented in the Figs. 1–3, 7–10, 12 and 15.

4 Conclusion

In the framework of Glauber's multiple scattering theory which takes into account both the full multiple scattering series of the Glauber amplitude and a consistent treatment of the center-of-mass correlation, we have studied the elastic scattering of deuteron with different nuclei like, $_3Li^6$, $_6C^{12}$, $_8O^{16}$, $_{12}Mg^{24}$, $_{16}S^{32}$, $_{20}Ca^{40}$, $_{23}V^{50}$, $_{28}Ni^{58}$, $_{32}Ge^{70}$ and $_{32}Ge^{72}$ at intermediate energies ($25 \leqslant E/A \leqslant 342.5$). We have calculated the angular distribution ($\frac{\sigma}{\sigma_{RUTH}}$ or $\frac{d\sigma}{d\Omega}$) for the above considered reactions and compared our results with the corresponding experimental data. It was shown that, in general, a smaller shift is appeared around the minimum in most of the theoretical results and a disagreement at large scattering angles is also exist there. Trial to overcome these drawbacks is made by investigating the effect of invoking a phase-variation in the NN scattering amplitude. Although the results show that a better agreement with the experimental data is obtained, especially at the minima of the diffraction patterns in comparison with the free-phase calculations, the introduction of such phase alone is not sufficient to bring the Glauber model prediction closer to the experimental data, except for a few number of the considered energies. The reason for the insignificance of this phase at large scatteing angles may be attributed to the followings: First, The complicated eclipse occurred from the multiple scattering collisions between nucleons which are not simple (linear) in its dependence on q^2 as that taken here. Second, the utilized bare NN parameters that neglecting the in-medium effect. Thus, for serious phase effect investigation, one should use a more realistic density distribution for the deuteron and effective NN parameters that account for the density dependence and the medium effect. This will be the subject of our future work.

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Appendix

This appendix contains the tables of the orbits, lengths and Δ-matrices employed in our calculations. We obtained them by enumerating and investigating all the possible combinations of collisions according to their pertation [20]. In the present work, the elastic collisions, d-$_3$Li^6, d-$_6$C^{12}, d-$_8$O^{16}, d-$_{12}$Mg^{24}, d-$_{16}$S^{32}, d-$_{20}$Ca^{40}, d-$_{23}$V^{50}, d-$_{28}$Ni^{58}, d-$_{32}$Ge^{70} and d-$_{32}$Ge^{72} have been studied according to their cluster and nucleon structures. The orbits, lengths and Δ-matrices of the groups $G_1 = S_{M_A} \otimes S_{M_B}$ and $G_2 = S_{M_N} \otimes S_{M_N}$ (defined in Section 2) corresponding to these reactions depend on the assumed cluster and nucleon configurations.

The numbers (M_A, M_B, M_N), determining the cluster and nucleon structures assumed in each system are taken as follows: $M_A = 1$, $M_N = 2$ while M_B is different for each reaction and it is equal to $B/2$, where B is the mass number of the target nucleus.

For the sake of brevity, we give only the tables of the non-similar groups.

μ	λ_μ	$T(\mu,\lambda_\mu)$	$\Delta(\mu,\lambda_\mu)$
1	1	29	10000000000000000000000000000
2	1	406	11000000000000000000000000000
3	1	3654	11100000000000000000000000000
4	1	23751	11110000000000000000000000000
5	1	118755	11111000000000000000000000000
6	1	475020	11111100000000000000000000000
7	1	1560780	11111110000000000000000000000
8	1	4292145	11111111000000000000000000000
9	1	10015005	11111111100000000000000000000
10	1	20030010	11111111110000000000000000000
11	1	34597290	11111111111000000000000000000
12	1	51895935	11111111111100000000000000000
13	1	67863915	11111111111110000000000000000
14	1	77558760	11111111111111000000000000000

Table 3: Orbits, lengths and Δ-matrices for $G = S_1 \otimes S_{29}$. Total number of orbits (including the orbits not shown) = 29.

μ	λ_μ	$T(\mu,\lambda_\mu)$	$\Delta(\mu,\lambda_\mu)$
1	1	29	10000000000000000000000000000
2	1	190	11000000000000000000000000000
3	1	1140	11100000000000000000000000000
4	1	4845	11110000000000000000000000000
5	1	15504	11111000000000000000000000000
6	1	38760	11111100000000000000000000000
7	1	77520	11111110000000000000000000000
8	1	125970	11111111000000000000000000000
9	1	167960	11111111100000000000000000000
10	1	184756	11111111110000000000000000000

Table 4: Orbits, lengths and – matrices for $G = S_1 \otimes S_{20}$. Total number of orbits (including the orbits not shown) = 20.

μ	λ_μ	$T(\mu,\lambda_\mu)$	$\Delta(\mu,\lambda_\mu)$
1	1	25	10000000000000000000000000000
2	1	300	11000000000000000000000000000
3	1	2300	11100000000000000000000000000
4	1	12650	11110000000000000000000000000
5	1	53130	11111000000000000000000000000
6	1	177100	11111100000000000000000000000
7	1	480700	11111110000000000000000000000
8	1	1081575	11111111000000000000000000000
9	1	2042975	11111111100000000000000000000
10	1	3268760	11111111110000000000000000000
11	1	4457400	11111111111000000000000000000
12	1	5200300	11111111111100000000000000000

Table 5: Orbits, lengths and Δ-matrices for $G = S_1 \otimes S_{25}$. Total number of orbits (including the orbits not shown) = 25.

μ	λ_μ	$T(\mu,\lambda_\mu)$	$\Delta(\mu,\lambda_\mu)$
1	1	3	100

Table 6: Orbits, lengths and Δ-matrices for $G = S_1 \otimes S_3$. Total number of orbits (including the orbits not shown) $= 3$.

μ	λ_μ	$T(\mu,\lambda_\mu)$	$\Delta(\mu,\lambda_\mu)$
1	1	35	10000000000000000000000000000
2	1	595	11000000000000000000000000000
3	1	6545	11100000000000000000000000000
4	1	52360	11110000000000000000000000000
5	1	324632	11111000000000000000000000000
6	1	1623160	11111100000000000000000000000
7	1	6724520	11111110000000000000000000000
8	1	23535820	11111111000000000000000000000
9	1	70607460	11111111100000000000000000000
10	1	1.835794E8	11111111110000000000000000000
11	1	4.172259E8	11111111111000000000000000000
12	1	8.344518E8	11111111111100000000000000000
13	1	1.4763378E9	11111111111110000000000000000
14	1	2.3199594E9	11111111111111000000000000000
15	1	3.2479432E9	111111111111111000000000000000
16	1	4.0599289E9	111111111111111100000000000000
17	1	4.5375676E9	111111111111111110000000000000

Table 7: Orbits, lengths and Δ-matrices for $G = S_1 \otimes S_{35}$. Total number of orbits (including the orbits not shown) $= 35$.

μ	λ_μ	$T(\mu,\lambda_\mu)$	$\Delta(\mu,\lambda_\mu)$
1	1	36	10000000000000000000000000000
2	1	630	11000000000000000000000000000
3	1	7140	11100000000000000000000000000
4	1	58905	11110000000000000000000000000
5	1	376992	11111000000000000000000000000
6	1	1947792	11111100000000000000000000000
7	1	8347680	11111110000000000000000000000
8	1	302660340	11111111000000000000000000000
9	1	94143280	11111111100000000000000000000
10	1	2.5418686E8	11111111110000000000000000000
11	1	6.008053E8	11111111111000000000000000000
12	1	1.2516777E9	11111111111100000000000000000
13	1	2.3107896E9	11111111111110000000000000000
14	1	3.7962972E9	11111111111111000000000000000
15	1	5.5679026E9	111111111111111000000000000000
16	1	7.3078721E9	111111111111111100000000000000
17	1	8.5974966E9	111111111111111110000000000000
18	1	9.0751353E9	111111111111111111000000000000

Table 8: Orbits, lengths and Δ-matrices for $G = S_1 \otimes S_{36}$. Total number of orbits (including the orbits not shown) $= 36$.

In these tables, the first column represents the order of multiple scattering μ which ranges from 1 to $1 \times n$ while λ_μ in the second column represents the serial index used to number the orbits of order μ. The third column represents the length of the orbit $T(\mu, \lambda_\mu)$. In the fourth column the $(1 \times n)$ - digit binary numbers give the Δ-matrices of the group $G = S_1 \otimes S_n$. The n-digits are the elements Δ_{1i}, where $i = 1, 2, \ldots, n$.

By symmetry, the orbits, lengths and Δ-matrices for $\mu's$ which are not shown in our tables could be easily deduced from the Tables. This is carried out by using the results for order $\mu' = m \times n - \mu$ and interchanging the $0's$ and $1's$ of $\Delta(\mu', \lambda_{\mu'})$. The indices λ_μ and $\lambda_{\mu'}$ are the same and the lengths $T(\mu, \lambda_\mu)$ and $T(\mu', \lambda_{\mu'})$ are equal. The matrix $\Delta(n, 1)$ has elements Δ_{1j} equal to 1.

The orbits, lengths and Δ-matrices of the groups $G = S_2 \otimes S_2$ [24] & $S_1 \otimes S_6$ & $S_1 \otimes S_{12}$ & $S_1 \otimes S_{16}$ [26] and $S_1 \otimes S_8$ [28] are also used to carry out our present calculations in addition to what was listed above.

Funnel's Fluctuations in Dyonic Case: Intersecting D1–D3 Branes

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The fluctuations of funnel solutions of intersecting D1 and D3 branes are quite explicitly discussed by treating different modes and different directions of the fluctuation at the presence of world volume electric field. The boundary conditions are found to be Neumann boundary conditions.

1 Introduction

D-branes described by Non-abelian Born-Infeld (BI) action [1] have many fascinating features. Among these there is the possibility for D-branes to morph into other D-branes of different dimensions by exciting some of the scalar fields [2, 3]. It's known in the literature that there are many different but physically equivalent descriptions of how a D1-brane may end on a D3-brane. From the point of view of the D3 brane the configuration is described by a monopole on its world volume. From the point of view of the D1-brane the configuration is described by the D1-brane opening up into a D3-brane where the extra three dimensions form a fuzzy two-sphere whose radius diverges at the origin of the D3-brane. These different view points are the stringy realization of the Nahm transformation [4, 5]. Also the dynamics of the both bion spike [2, 6] and the fuzzy funnel [5, 7, 8] were studied by considering linearized fluctuations around the static solutions.

The present work is devoted to study the fluctuations of funnel solutions in the presence of a world-volume electric field. By discussing the solutions and the potentials for this particular case we end by the system D1⊥D3 branes gets a special property because of the presence of electric field; the system is divided to two regions corresponding to small and large electric field. Consequently, the system has Neumann boundary conditions and the end of open string can move freely on the brane which is agree with its dual discussed in [9] considering Born-Infeld action dealing with the fluctuation of the bion skipe in D3⊥D1-case.

The paper is organized as follows: In section 2, we start by a brief review on D1⊥D3 branes in dyonic case by using the non-Born-Infeld action. Then, we discuss the fluctuations of the fuzzy funnel in section 3 for zero and high modes. We give the solutions of the linearized equations of motion of the fluctuations for both cases the overall transverse and the relative one. We also discuss the solutions and the potential depending on the presence of electric field which is leading to Neumann boundary conditions as special property of the system. Then the waves on the brane cause the fuzzy funnel to freely oscillate.

2 D1⊥D3 branes with electric field swished on

In this section, we review in brief the funnel solutions for D1⊥D3 branes from D3 and D1 branes points of view. First, using abelian BI action for the world-volume gauge field and one excited transverse scalar in dyonic case, we give the funnel solution. It was showed in [10] that the BI action, when taken as the fundamental action, can be used to build a configuration with a semi-infinite fundamental string ending on a D3-brane [11]. The dyonic system is given by using D-string world-volume theory and the fundamental strings introduced by adding a $U(1)$ electric field. Thus the system is described by the following action

$$\begin{aligned} S &= \int dt L = \\ &= -T_3 \int d^4\sigma \sqrt{-\det(\eta_{ab} + \lambda^2\,\partial_a\phi^i\,\partial_b\phi^i + \lambda F_{ab})} = \\ &= -T_3 \int d^4\sigma \Big[1 + \lambda^2\Big(|\nabla\phi|^2 + B^2 + E^2\Big) + \\ &+ \lambda^4\Big((B\cdot\nabla\phi)^2 + (E\cdot B)^2 + |E\wedge\nabla\phi|^2\Big)\Big]^{\frac{1}{2}} \end{aligned} \tag{1}$$

in which F_{ab} is the field strength and the electric field is denoted as $F_{09} = EI_{ab}$, (I_{ab} is $N\times N$ matrix). σ^a $(a=0,\dots,3)$ denote the world volume coordinates while ϕ^i $(i=4,\dots,9)$ are the scalars describing transverse fluctuations of the brane and $\lambda = 2\pi\ell_s^2$ with ℓ_s is the string length. In our case we excite just one scalar so $\phi^i = \phi^9 \equiv \phi$. Following the same process used in the reference [10] by considering static gauge, we look for the lowest energy of the system. Accordingly to (1) the energy of dyonic system is given as

$$\begin{aligned} \Xi = T_3 \int d^3\sigma \Big[\,&\lambda^2|\nabla\phi + \vec{B} + \vec{E}|^2 + (1 - \lambda^2\,\nabla\phi\cdot\vec{B})^2 - \\ &- 2\lambda^2\vec{E}\cdot(\vec{B} + \nabla\phi) + \lambda^4\Big((\vec{E}\cdot\vec{B})^2 + |\vec{E}\wedge\nabla\phi|^2\Big)\Big]^{\frac{1}{2}}, \end{aligned} \tag{2}$$

then if we require $\nabla\phi + \vec{B} + \vec{E} = 0$, Ξ reduces to $\Xi_0 \geqslant 0$ and we find

$$\begin{aligned} \Xi_0 = T_3 \int d^3\sigma \Big[&\big(1 - \lambda^2\,(\nabla\phi)\cdot\vec{B}\big)^2 + 2\lambda^2\vec{E}\cdot\vec{E} + \\ &+ \lambda^4\left((\vec{E}\cdot\vec{B})^2 + |\vec{E}\Lambda\nabla\phi|^2\right)\Big]^{\frac{1}{2}} \end{aligned} \tag{3}$$

as minimum energy. By using the Bianchi identity $\nabla\cdot B=0$ and the fact that the gauge field is static, the funnel solution is then

$$\phi = \frac{N_m + N_e}{2r}\,, \tag{4}$$

with N_m is magnetic charge and N_e electric charge.

Now we consider the dual description of the $D1\perp D3$ from D1 branes point of view. To get D3-branes from D-strings, we use the non-abelian BI action

$$S = -T_1 \int d^2\sigma \times \times \mathrm{Str}\Big[-\det(\eta_{ab} + \lambda^2\,\partial_a\phi^i\,Q^{-1}_{ij}\,\partial_b\phi^j)\det Q^{ij}\Big]^{\frac{1}{2}} \tag{5}$$

where $Q_{ij}=\delta_{ij}+i\lambda\big[\phi_i,\phi_j\big]$. Expanding this action to leading order in λ yields the usual non-abelian scalar action

$$S \cong -T_1\int d^2\sigma \times \times\Big[N + \lambda^2\,\mathrm{tr}\left(\partial_a\phi^i + \tfrac{1}{2}\big[\phi_i,\phi_j\big]\big[\phi_j,\phi_i\big]\right) + \ldots\Big]^{\frac{1}{2}}.$$

The solutions of the equation of motion of the scalar fields ϕ_i, $i=1,2,3$ represent the D-string expanding into a D3-brane analogous to the bion solution of the D3-brane theory [2, 3]. The solutions are

$$\phi_i = \pm\frac{\alpha_i}{2\sigma}, \qquad \big[\alpha_i,\alpha_j\big] = 2i\epsilon^{ijk}\alpha_k,$$

with the corresponding geometry is a long funnel where the cross-section at fixed σ has the topology of a fuzzy two-sphere.

The dyonic case is taken by considering (N,N_f)-strings. We have N D-strings and N_f fundamental strings [5]. The theory is described by the action

$$S = -T_1\int d^2\sigma \times \times\mathrm{Str}\Big[-\det(\eta_{ab}+\lambda^2\partial_a\phi^i Q^{-1}_{ij}\partial_b\phi^j+\lambda E I_{ab})\det Q^{ij}\Big]^{\frac{1}{2}} \tag{6}$$

in which we replaced the field strength F_{ab} by EI_{ab} (I_{ab} is $N\times N$-matrix) meaning that the fundamental string is introduced by adding a $U(1)$ electric field E.

The action can be rewritten as

$$S = -T_1\int d^2\sigma\,\mathrm{Str}\left[-\det\begin{pmatrix}\eta_{ab}+\lambda E I_{ab} & \lambda\partial_a\phi^j\\ -\lambda\partial_b\phi^i & Q^{ij}\end{pmatrix}\right]^{\frac{1}{2}}, \tag{7}$$

then the bound states of D-strings and fundamental strings are made simply by introducing a background $U(1)$ electric field on D-strings, corresponding to fundamental strings dissolved on the world-sheet. By computing the determinant, the action becomes

$$S = -T_1\int d^2\sigma \times \times\mathrm{Str}\Big[(1-\lambda^2E^2+\alpha_i\alpha_i\hat{R}'^2)(1+4\lambda^2\alpha_j\alpha_j\hat{R}^4)\Big]^{\frac{1}{2}}, \tag{8}$$

where the following ansatz were inserted

$$\phi_i = \hat{R}\alpha_i\,. \tag{9}$$

Hence, we get the funnel solution for dyonic string by solving the equation of variation of $\hat{R}$, as follows

$$\phi_i = \frac{\alpha_i}{2\sigma\sqrt{1-\lambda^2E^2}}. \tag{10}$$

3 Fluctuations of dyonic funnel solutions

In this section, we treat the dynamics of the funnel solutions. We solve the linearized equations of motion for small and time-dependent fluctuations of the transverse scalar around the exact background in dyonic case.

We deal with the fluctuations of the funnel (10) discussed in the previous section. By plugging into the full $(N-N_f)$ string action (6, 7) the "overall transverse" $\delta\phi^m(\sigma,t) = f^m(\sigma,t)\,I_N$, $m=4,\ldots,8$ which is the simplest type of fluctuation with I_N the identity matrix, together with the funnel solution, we get

$$S = -T_1\int d^2\sigma\,\mathrm{Str}\Big[(1+\lambda E)\Big(1+\frac{\lambda^2\alpha^i\alpha^i}{4\sigma^4}\Big)\times \times\Big(\Big(1+\frac{\lambda^2\alpha^i\alpha^i}{4\sigma^4}\Big)\big(1+(\lambda E-1)\lambda^2(\partial_t\delta\phi^m)^2\big) + +\lambda^2(\partial_\sigma\delta\phi^m)^2\Big)\Big]^{\frac{1}{2}} \approx -NT_1\int d^2\sigma H\Big[(1+\lambda E) - -(1-\lambda^2E^2)\frac{\lambda^2}{2}(\dot{f}^m)^2 + \frac{(1+\lambda E)\lambda^2}{2H}(\partial_\sigma f^m)^2+\ldots\Big] \tag{11}$$

where

$$H = 1+\frac{\lambda^2C}{4\sigma^4}$$

and $C=\mathrm{tr}\,\alpha^i\alpha^i$. For the irreducible $N\times N$ representation we have $C=N^2-1$. In the last line we have only kept the terms quadratic in the fluctuations as this is sufficient to determine the linearized equations of motion

$$\left((1-\lambda E)\left(1+\lambda^2\frac{N^2-1}{4\sigma^4}\right)\partial_t^2 - \partial_\sigma^2\right)f^m = 0\,. \tag{12}$$

In the overall case, all the points of the fuzzy funnel move or fluctuate in the same direction of the dyonic string by an equal distance δx^m. First, the funnel solution is $\phi^i = \frac{1}{2\sqrt{1-\lambda^2E^2}}\frac{\alpha^i}{\sigma}$ and the fluctuation f^m waves in the direction of x^m;

$$f^m(\sigma,t) = \Phi(\sigma)\,e^{-iwt}\delta x^m. \tag{13}$$

With this ansatz the equation of motion is

$$\Big((1-\lambda E)Hw^2+\partial_\sigma^2\Big)\Phi(\sigma) = 0\,, \tag{14}$$

then the problem is reduced to finding the solution of a single scalar equation.

Thus, we remark that the equation (14) is an analog one-dimensional Schrödinger equation and it can be rewritten as

$$\Big(-\partial_\sigma^2 + V(\sigma)\Big)\,\Phi(\sigma) = w^2\,(1-\lambda E)\,\Phi(\sigma), \qquad (15)$$

with

$$V(\sigma) = w^2(\lambda E - 1)\,\lambda^2\,\frac{N^2-1}{4\sigma^4}.$$

We notice that, if the electric field dominates $E \gg 1$, the potential goes to $w^2\lambda^3 E\frac{N^2}{4\sigma^4}$ for large N and if $E \ll 1$ we find $V = -\,w^2\,\lambda^2\,\frac{N^2}{4\sigma^4}$. This can be seen as two separated systems depending on electric field so we have Neumann boundary condition separating the system into two regions $E \gg 1$ and $E \ll 1$.

Now, let's find the solution of a single scalar equation (14). First, the equation (14) can be rewritten as follows

$$\left(\frac{1}{w^2(1-\lambda E)}\,\partial_\sigma^2 + 1 + \frac{\lambda^2 N^2}{4\sigma^4}\right)\Phi(\sigma) = 0\,, \qquad (16)$$

for large N. If we suggest $\tilde\sigma = w\sqrt{1-\lambda E}\,\sigma$ the latter equation becomes

$$\left(\partial_{\tilde\sigma}^2 + 1 + \frac{\kappa^2}{\tilde\sigma^4}\right)\Phi(\tilde\sigma) = 0\,, \qquad (17)$$

with the potential is

$$V(\tilde\sigma) = \frac{\kappa^2}{\tilde\sigma^4}\,, \qquad (18)$$

and $\kappa = \frac{\lambda N w^2}{2}(1-\lambda E)$. This equation is a Schrödinger equation for an attractive singular potential $\propto \tilde\sigma^{-4}$ and depends on the single coupling parameter κ with constant positive Schrödinger energy. The solution is then known by making the following coordinate change

$$\chi(\tilde\sigma) = \int_{\sqrt{\kappa}}^{\tilde\sigma} dy\,\sqrt{1+\frac{\kappa^2}{y^4}}\,, \qquad (19)$$

and

$$\Phi = \left(1+\frac{\kappa^2}{\tilde\sigma^4}\right)^{-\frac{1}{4}}\tilde\Phi\,. \qquad (20)$$

Thus, the equation (17) becomes

$$\Big(-\partial_\chi^2 + V(\chi)\Big)\tilde\Phi = 0\,, \qquad (21)$$

with

$$V(\chi) = \frac{5\kappa^2}{\left(\tilde\sigma^2 + \frac{\kappa^2}{\tilde\sigma^2}\right)^3}\,. \qquad (22)$$

Then, the fluctuation is found to be

$$\Phi = \left(1+\frac{\kappa^2}{\tilde\sigma^4}\right)^{-\frac{1}{4}} e^{\pm i\chi(\tilde\sigma)}. \qquad (23)$$

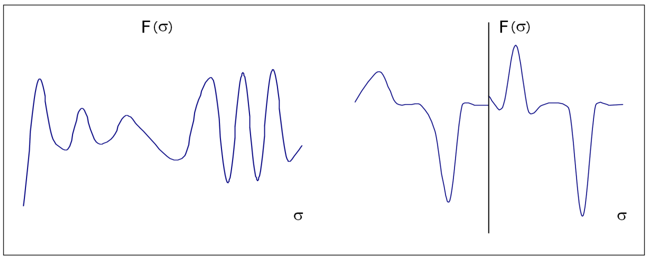

Fig. 1: Left hand curve represents the overall fluctuation wave in zero mode and low electric field. Right hand curve shows the scattering of the overall fluctuation wave in zero mode and high electric field. This latter caused a discontinuity of the wave which means Neumann boundary condition.

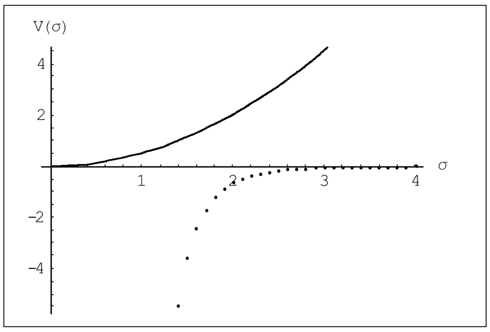

Fig. 2: The up line shows the potential in zero mode of the overall funnel's fluctuations at the absence of electric field E and the dots represent the potential in the same mode at the presence of E. The presence of E is changing the potential totally to the opposite.

This fluctuation has the following limits; at large σ, $\Phi \sim e^{\pm i\chi(\tilde\sigma)}$ and if σ is small $\Phi = \frac{\sqrt{\kappa}}{\tilde\sigma}e^{\pm i\chi(\tilde\sigma)}$. These are the asymptotic wave function in the regions $\chi \to \pm\infty$, while around $\chi \sim 0$; i.e. $\tilde\sigma \sim \sqrt{\kappa}$, $f^m \sim 2^{-\frac{1}{4}}e^{-iwt}\delta x^m$ (Fig. 1).

The potential (22) in large and small limits of electric field becomes (Fig. 2):

- $E \gg 1$, $V(\chi) \sim \frac{-5\lambda N^2}{E\sigma^6}$;
- $E \ll 1$, $V(\chi) \sim \frac{5\lambda^2 N^2 w^2}{4\left(w^2\sigma^2 + \frac{\lambda^2 N^2 w^2}{4\sigma^2}\right)}$.

At the presence of electric field we remark that around $\sigma \sim 0$ there is a symmetric potential which goes to zero very fast and more fast as electric field is large $\sim \frac{-1}{E\sigma^2}$. As discussed above, again we get the separated systems in different regions depending on the values of electric field. Also if we have a look at the fluctuation (23) we find that f^m in the case of $E \gg 1$ is different from the one in $E \ll 1$ case and as shown in the Fig. 1 the presence of electric field causes a discontinuity of the fluctuation wave which means free boundary condition. Contrarily, at the absence of electric field the fluctuation wave is continue. Then, this is seen as Neumann boundary condition from non-Born-Infeld dynamics separating the system into two regions $E \gg 1$ and $E \ll 1$ which is agree with its dual discussed in [9].

The fluctuations discussed above could be called the zero mode $\ell = 0$ and for high modes $\ell \geqslant 0$, the fluctuations are

$$\delta\phi^m(\sigma,t) = \sum_{\ell=0}^{N-1} \psi^m_{i_1\dots i_\ell}\alpha^{i_1}\dots\alpha^{i_\ell}$$

with $\psi^m_{i_1\dots i_\ell}$ are completely symmetric and traceless in the lower indices.

The action describing this system is

$$\begin{aligned} S \approx -NT_1 \int d^2\sigma \Big[(1+\lambda E)H - (1-\lambda^2E^2)\times \\ \times H\frac{\lambda^2}{2}(\partial_t\delta\phi^m)^2 + \frac{(1+\lambda E)\lambda^2}{2H}(\partial_\sigma\delta\phi^m)^2 - \\ -(1-\lambda^2E^2)\frac{\lambda^2}{2}\big[\phi^i,\delta\phi^m\big]^2 - \frac{\lambda^4}{12}\big[\partial_\sigma\phi^i,\partial_t\delta\phi^m\big]^2 + \dots\Big] \end{aligned} \tag{24}$$

Now the linearized equations of motion are

$$\begin{aligned} \Big[(1+\lambda E)H\partial_t^2 - \partial_\sigma^2\Big]\delta\phi^m + (1-\lambda^2E^2)\times \\ \times\big[\phi^i,\big[\phi^i,\delta\phi^m\big]\big] - \frac{\lambda^2}{6}\big[\partial_\sigma\phi^i,\big[\partial_\sigma\phi^i,\partial_t^2\delta\phi^m\big]\big] = 0\,. \end{aligned} \tag{25}$$

Since the background solution is $\phi^i \propto \alpha^i$ and we have $\big[\alpha^i,\alpha^j\big] = 2i\epsilon_{ijk}\alpha^k$, we get

$$\begin{aligned} \big[\alpha^i,\big[\alpha^i,\delta\phi^m\big]\big] &= \sum_{\ell<N}\psi^m_{i_1\dots i_\ell}\big[\alpha^i,\big[\alpha^i,\alpha^{i_1}\dots\alpha^{i_\ell}\big]\big] \\ &= \sum_{\ell<N} 4\ell(\ell+1)\psi^m_{i_1\dots i_\ell}\alpha^{i_1}\dots\alpha^{i_\ell} \end{aligned} \tag{26}$$

To obtain a specific spherical harmonic on 2-sphere, we have

$$\begin{aligned} \big[\phi^i,\big[\phi^i,\delta\phi^m_\ell\big]\big] &= \frac{\ell(\ell+1)}{\sigma^2}\,\delta\phi^m_\ell\,, \\ \big[\partial_\sigma\phi^i,\big[\partial_\sigma\phi^i,\partial_t^2\delta\phi^m\big]\big] &= \frac{\ell(\ell+1)}{\sigma^4}\,\partial_t^2\delta\phi^m_\ell\,. \end{aligned} \tag{27}$$

Then for each mode the equations of motion are

$$\begin{aligned} \bigg[\bigg((1+\lambda E)\Big(1+\lambda^2\frac{N^2-1}{4\sigma^4}\Big) - \frac{\lambda^2\ell(\ell+1)}{6\sigma^4}\bigg)\partial_t^2 - \\ -\partial_\sigma^2 + (1-\lambda^2E^2)\frac{\ell(\ell+1)}{\sigma^2}\bigg]\delta\phi^m_\ell = 0\,. \end{aligned} \tag{28}$$

The solution of the equation of motion can be found by taking the following proposal. Let's consider $\phi^m_\ell = f^m_\ell(\sigma)e^{-iwt}\delta x^m$ in direction m with $f^m_\ell(\sigma)$ is some function of σ for each mode ℓ.

The last equation can be rewritten as

$$\Big[-\partial_\sigma^2 + V(\sigma)\Big]f^m_\ell(\sigma) = w^2(1+\lambda E)\,f^m_\ell(\sigma)\,, \tag{29}$$

with

$$\begin{aligned} V(\sigma) = -w^2\bigg((1+\lambda E)\frac{\lambda^2N^2}{4\sigma^4} - \frac{\lambda^2\ell(\ell+1)}{6\sigma^4}\bigg) + \\ +(1-\lambda^2E^2)\frac{\ell(\ell+1)}{\sigma^2}\,. \end{aligned}$$

Let's write the equation (29) in the following form

$$\begin{aligned} \bigg[w^2\bigg((1+\lambda E)H - \frac{\lambda^2\ell(\ell+1)}{6\sigma^4}\bigg) - \\ -(1-\lambda^2E^2)\frac{\ell(\ell+1)}{\sigma^2} + \partial_\sigma^2\bigg]f^m_\ell(\sigma) = 0\,. \end{aligned} \tag{30}$$

and again as

$$\begin{aligned} \bigg[1 + \frac{1}{\sigma^4}\bigg(\lambda^2\frac{N^2-1}{4} - \frac{\lambda^2\ell(\ell+1)}{6(1+\lambda E)}\bigg) - \\ -(1-\lambda E)\frac{\ell(\ell+1)}{w^2\sigma^2} + \frac{1}{w^2(1+\lambda E)}\partial_\sigma^2\bigg]f^m_\ell(\sigma) = 0\,. \end{aligned} \tag{31}$$

We define new coordinate $\tilde\sigma = w\sqrt{1+\lambda E}\,\sigma$ and the latter equation becomes

$$\bigg[\partial_{\tilde\sigma}^2 + 1 + \frac{\kappa^2}{\tilde\sigma^4} + \frac{\eta}{\tilde\sigma^2}\bigg]f^m_\ell(\sigma) = 0\,, \tag{32}$$

where

$$\kappa^2 = w^2(1+\lambda E)\bigg(\lambda^2\frac{N^2-1}{4} - \frac{\lambda^2\ell(\ell+1)}{6(1+\lambda E)}\bigg)^{\frac{1}{2}},$$

$$\eta = -(1-\lambda^2E^2)\,\ell(\ell+1)$$

such that

$$N > \sqrt{\frac{2\ell(\ell+1)}{3(1+\lambda E)} + 1}\,.$$

For simplicity we choose small σ, then the equation (32) is reduced to

$$\bigg[\partial_{\tilde\sigma}^2 + 1 + \frac{\kappa^2}{\tilde\sigma^4}\bigg]f^m_\ell(\sigma) = 0\,, \tag{33}$$

as we did in zero mode, we get the solution by using the steps (19–22) with new κ. Since we considered small σ we get

$$V(\chi) = \frac{5\tilde\sigma^6}{\kappa^4}\,,$$

then

$$f^m_\ell = \frac{\tilde\sigma}{\sqrt{\kappa}}\,e^{\pm i\chi(\tilde\sigma)}\,. \tag{34}$$

This fluctuation has two different values at large E and small E (Fig. 3) and a closer look at the potential at large and fixed N in large and small limits of electric field leads to

- $E \gg 1$, $V(\chi) \sim \frac{20w^2E\sigma^6}{\lambda N^2}$;
- $E \ll 1$, $V(\chi) \sim \frac{5w^2\sigma^6}{\lambda^2\left(\frac{N^2}{4} - \frac{\ell(\ell+1)}{6}\right)}$.

The potential in the first case is going fast to infinity than the one in the second case because of the electric field if $\sigma \ll 1$ (Fig. 4).

For large σ the equation of motion (30) of the fluctuation becomes

$$\Big[-\partial_\sigma^2 + \tilde V(\sigma)\Big]f^m_\ell(\sigma) = w^2(1+\lambda E)f^m_\ell(\sigma)\,, \tag{35}$$

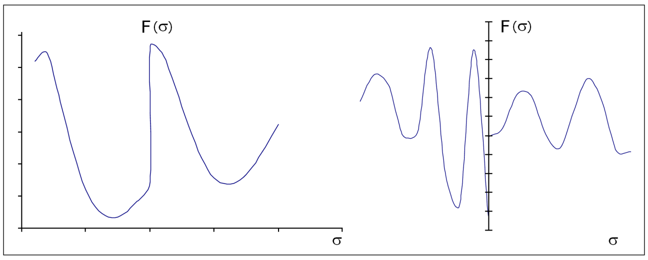

Fig. 3: The left figure shows the continuity of the fluctuation wave in high mode of the overall fluctuation at the absence of electric field E. The right figure shows the discontinuity of the wave at the presence of E in high mode meaning free boundary condition.

with $\tilde{V}(\sigma) = \frac{(1-\lambda^2 E^2)\,\ell(\ell+1)}{\sigma^2}$ and f_ℓ^m is now a Sturm-Liouville eigenvalue problem (Fig. 3). We found that the fluctuation has discontinuity at the presence of electric field meaning free boundary condition. Also we remark that the potential has different values in the different regions of electric field $E \gg 1$ and $E \ll 1$ and this time for large σ. In this side, the potential drops with opposite sign from one case to other and as shown in (Fig. 4). The presence of E is changing the potential totally to the opposite in both cases zero and high modes.

Consequently, by discussing explicitly the fluctuations and the potential of intersecting D1-D3 branes in D1-brane world volume theory we found that the system has Neumann boundary conditions and the end of the string can move freely on the brane for both zero and high modes of the overall transverse fluctuations case.

3.1 Relative Transverse Fluctuations

Now if we consider the "relative transverse" $\delta\phi^i(\sigma,t) = f^i(\sigma,t)\,I_N$, $i=1,2,3$ the action is

$$S = -T_1 \int d^2\sigma \times \times \mathrm{Str}\left[-\det\begin{pmatrix} \eta_{ab}+\lambda E I_{ab} & \lambda\partial_a(\phi^j+\delta\phi^j) \\ -\lambda\partial_b(\phi^i+\delta\phi^i) & Q_*^{ij}\end{pmatrix}\right]^{\frac{1}{2}}, \tag{36}$$

with $Q_*^{ij} = Q^{ij} + i\lambda\big([\phi_i,\delta\phi_j] + [\delta\phi_i,\phi_j] + [\delta\phi_i,\delta\phi_j]\big)$. As before we keep only the terms quadratic in the fluctuations and the action becomes

$$S \approx -NT_1 \int d^2\sigma \Big[(1-\lambda^2 E^2)\,H - (1-\lambda E)\frac{\lambda^2}{2}(\dot{f}^i)^2 + \frac{(1+\lambda E)\lambda^2}{2H}(\partial_\sigma f^i)^2 + \dots\Big]. \tag{37}$$

Then the equations of motion of the fluctuations are

$$\left(-\partial_\sigma^2 - w^2\frac{1-\lambda E}{1+\lambda E}\,\lambda^2\,\frac{N^2-1}{4\sigma^4}\right) f^i = w^2\frac{1-\lambda E}{1+\lambda E} f^i. \tag{38}$$

If we write $f^i = \Phi^i(\sigma)\,e^{-iwt}\delta x^i$ in the direction of x^i, the potential will be

$$V(\sigma) = -\frac{1-\lambda E}{1+\lambda E}\,\lambda^2\,\frac{N^2-1}{4\sigma^4}\,w^2.$$

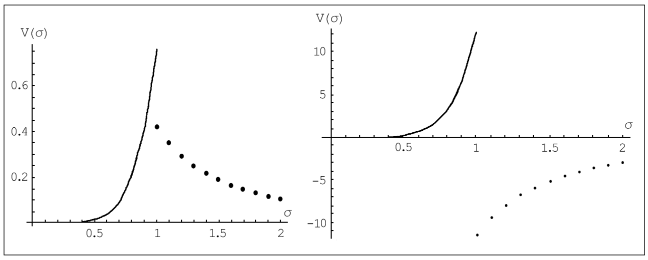

Fig. 4: The line represents the potential for small σ and dots for large σ in both figures. In high mode of overall fluctuations at the absence of electric field E, the left figure shows high potential at some stage of σ where the two curves meet. The right figure shows a critical case. The curves represent the potentials at the presence of E for small and large σ. As a remark, there is no intersecting point for theses two potentials! At some stage of σ there is a singularity.

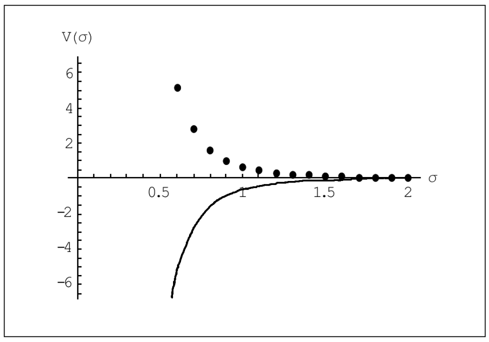

Fig. 5: The line shows the potential in zero mode of the relative funnel's fluctuations at the absence of electric field E and the dots represent the potential in the same mode at the presence of E. The presence of E is changing the potential totally to the opposite.

Let's discuss the cases of electric field:

- $E \ll 1$, $V(\sigma) \sim -\lambda^2\frac{N^2-1}{4\sigma^4}w^2$;
- $E \gg 1$, $V(\sigma) \sim \lambda^2\frac{N^2-1}{4\sigma^4}w^2$.

Also in the relative case, this is Neumann boundary condition (Fig. 5) which can be also shown by finding the solution of (38) for which we follow the same way as above by making a coordinate change suggested by WKB. This case is seen as a zero mode of what is following so we will treat this in general case by using this coordinate change for high modes.

Now let's give the equation of motion of relative transverse fluctuations of high ℓ modes with $(N-N_f)$ strings intersecting D3-branes. The fluctuation is given by

$$\delta\phi^i(\sigma,t) = \sum_{\ell=1}^{N-1}\psi^i_{i_1\dots i_\ell}\alpha^{i_1}\dots\alpha^{i_\ell}$$

with $\psi^i_{i_1\dots i_\ell}$ are completely symmetric and traceless in the lower indices.

The action describing this system is

$$S \approx -NT_1 \int d^2\sigma \Big[(1-\lambda^2 E^2) H - \\ -(1-\lambda E) H \frac{\lambda^2}{2} (\partial_t \delta\phi^i)^2 + \frac{(1+\lambda E)\lambda^2}{2H} (\partial_\sigma \delta\phi^i)^2 - \\ -(1-\lambda E)\frac{\lambda^2}{2} \big[\phi^i, \delta\phi^i\big]^2 - \frac{\lambda^4}{12} \big[\partial_\sigma \phi^i, \partial_t \delta\phi^i\big]^2 + \ldots \Big]. \quad (39)$$

The equation of motion for relative transverse fluctuations in high mode is as follows

$$\left[\frac{1-\lambda E}{1+\lambda E} H \partial_t^2 - \partial_\sigma^2\right] \delta\phi^i + (1-\lambda E)\big[\phi^i, [\phi^i, \delta\phi^i]\big] - \\ - \frac{\lambda^2}{6} \big[\partial_\sigma \phi^i, [\partial_\sigma \phi^i, \partial_t^2 \delta\phi^i]\big] = 0 . \quad (40)$$

By the same way as done for overall transverse fluctuations the equation of motion for each mode is

$$\Big[-\partial_\sigma^2 + \Big(\frac{1-\lambda E}{1+\lambda E}\Big(1+\lambda^2 \frac{N^2-1}{4\sigma^4}\Big) - \frac{\lambda^2 \ell(\ell+1)}{6\sigma^4}\Big)\partial_t^2 + \\ + (1-\lambda E)\frac{\ell(\ell+1)}{\sigma^2}\Big] \delta\phi^i_\ell = 0 . \quad (41)$$

We take $\delta\phi^i_\ell = f^i_\ell \, e^{-iwt} \delta x^i$, then the equation (41) becomes

$$\Big[-\partial_\sigma^2 - \Big(\frac{1-\lambda E}{1+\lambda E}\Big(1+\lambda^2 \frac{N^2-1}{4\sigma^4}\Big) - \frac{\lambda^2 \ell(\ell+1)}{6\sigma^4}\Big) w^2 + \\ + (1-\lambda E)\frac{\ell(\ell+1)}{\sigma^2}\Big] f^i_\ell = 0 . \quad (42)$$

To solve the equation we choose for simplicity the boundaries of σ; For small σ, the equation is reduced to

$$\Big[-\partial_\sigma^2 - \Big(\frac{1-\lambda E}{1+\lambda E}\Big(1+\lambda^2 \frac{N^2-1}{4\sigma^4}\Big) - \\ - \frac{\lambda^2 \ell(\ell+1)}{6\sigma^4}\Big) w^2\Big] f^i_\ell = 0 , \quad (43)$$

which can be rewritten as follows

$$\Big[-\frac{1+\lambda E}{1-\lambda E}\partial_\sigma^2 - \Big(\Big(1+\lambda^2 \frac{N^2-1}{4\sigma^4}\Big) - \\ - \frac{1+\lambda E}{1-\lambda E}\frac{\lambda^2 \ell(\ell+1)}{6\sigma^4}\Big) w^2\Big] f^i_\ell = 0 . \quad (44)$$

We change the coordinate to $\tilde\sigma = \sqrt{\frac{1-\lambda E}{1+\lambda E}}\, w\sigma$ and the equation (44) becomes

$$\Big[\partial_{\tilde\sigma}^2 + 1 + \frac{\kappa^2}{\tilde\sigma^4}\Big] f^i_\ell(\tilde\sigma) = 0 , \quad (45)$$

with

$$\kappa^2 = w^4 \lambda^2 \, \frac{3(1-\lambda E)^2 (N^2-1) - 2(1-\lambda^2 E^2)\,\ell(\ell+1)}{12(1+\lambda E)^2} .$$

Then we follow the suggestions of WKB by making a coordinate change;

$$\beta(\tilde\sigma) = \int_{\sqrt{\kappa}}^{\tilde\sigma} dy \sqrt{1 + \frac{\kappa^2}{y^4}} , \quad (46)$$

and

$$f^i_\ell(\tilde\sigma) = \Big(1 + \frac{\kappa^2}{\tilde\sigma^4}\Big)^{-\frac14} \tilde f^i_\ell(\tilde\sigma) . \quad (47)$$

Thus, the equation (45) becomes

$$\Big(-\partial_\beta^2 + V(\beta)\Big)\tilde f^i = 0 , \quad (48)$$

with

$$V(\beta) = \frac{5\kappa^2}{\big(\tilde\sigma^2 + \frac{\kappa^2}{\tilde\sigma^2}\big)^3} . \quad (49)$$

Then

$$f^i_\ell = \Big(1 + \frac{\kappa^2}{\tilde\sigma^4}\Big)^{-\frac14} e^{\pm i\beta(\tilde\sigma)} . \quad (50)$$

The discussion is similar to the overall case; so the obtained fluctuation has the following limits; at large σ, $f^i_\ell \sim \sim e^{\pm i\beta(\tilde\sigma)}$ and if σ is small $f^i_\ell = \frac{\sqrt{\kappa}}{\tilde\sigma} e^{\pm i\beta(\tilde\sigma)}$. These are the asymptotic wave function in the regions $\beta \to \pm\infty$, while around $\beta \sim 0$; i.e. $\tilde\sigma \sim \sqrt{\kappa}$, $f^i_\ell \sim 2^{-\frac14}$.

Then let's have a look at the potential in various limits of electric field:

- $E \sim \frac{1}{\lambda}$, $V(\beta) \sim 0$;
- $E \gg 1$, $\kappa^2 \equiv \kappa^2_+ \sim w^4 \lambda^2 \frac{3(N^2-1)+2\ell(\ell+1)}{12}$, then $\sigma \sim 0 \Rightarrow V(\beta) \sim \frac{5\tilde\sigma^6}{\kappa^4_+}$;
- $E \ll 1$, $\kappa^2 \equiv \kappa^2_- \sim w^4 \lambda^2 \frac{3(N^2-1)-2\ell(\ell+1)}{12}$; for this case we get $\sigma \sim 0 \Rightarrow V(\beta) \sim \frac{5\tilde\sigma^6}{\kappa^4_-}$;

this means that we have a Neumann boundary condition with relative fluctuations at small σ (Fig. 6).

Now, if σ is too large the equation of motion (42) becomes

$$\Big[-\partial_\sigma^2 + (1-\lambda E)\frac{\ell(\ell+1)}{\sigma^2}\Big] f^i_\ell = \frac{1-\lambda E}{1+\lambda E} w^2 f^i_\ell . \quad (51)$$

We see, the associated potential $V(\sigma) = (1-\lambda E)\frac{\ell(\ell+1)}{\sigma^2}$ goes to $-\epsilon$ in the case of $E \gg 1$ and to $+\epsilon$ if $E \ll 1$ since σ is too large with $\epsilon \sim 0$, (Fig. 6). We get the same remark as before by dealing with the fluctuations for small and large σ (50) and solving (51) respectively, at the presence of electric field that we have two separated regions depending on the electric field (Fig. 7).

We discussed quite explicitly through this section the fluctuation of the funnel solution of D1⊥D3 branes by treating different modes and different directions of the fluctuation. We found that the system got an important property because of the presence of electric field; the system has Neumann boundary condition.

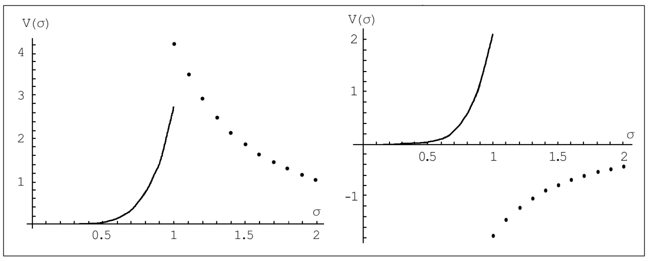

Fig. 6: As we saw in high mode of overall fluctuations, also for relative case we get high potential at some stage of σ where the the tow curves meet representing potentials for small and large σ at the absence of electric field E in the left figure. Right figure shows again a singularity this time in relative case because of the presence of E.

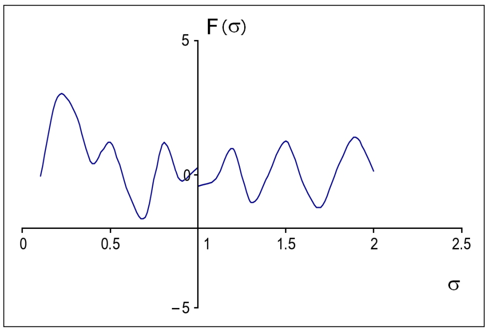

Fig. 7: The presence of electric field E causes a discontinuity of the wave in high mode of relative case meaning free boundary condition.

4 Conclusion

We have investigated the intersecting D1-D3 branes through a consideration of the presence of electric field. We have treated the fluctuations of the funnel solutions and we have discussed explicitly the potentials in both systems. We found a specific feature of the presence of electric field. When the electric field is going up and down the potential of the system is changing and the fluctuations of funnel solutions as well which cause the division of the system to tow regions. Consequently, the end point of the dyonic strings move on the brane which means we have Neumann boundary condition.

The present study is in flat background and there is another interesting investigation is concerning the perturbations propagating on a dyonic string in the supergravity background [12, 5] of an orthogonal 3-brane. Then we can deal with this important case and see if we will get the same boundary conditions by treating the dyonic fluctuations.

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On the Possibility of Nuclear Synthesis During Orthopositronium Formation by β^+-Decay Positrons in Deuterium

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Observations of the "isotopic anomaly" of positron (^{22}Na) annihilation lifetime spectra in samples of gaseous neon of various isotopic abundance, the independent observations of the orthopositronium lifetime anomaly, and comparison of unique experimental data on the positron's annihilation lifetime spectra in condensed deuterium (D_2) and protium (H_2), suggest a hypothesis on synthesis of ^{4}He during the orthopositronium formation in deuterium. The decisive experiment is offered.

1 Introduction

When a muon replaces an electron in a two-centre "molecular ion" of light nuclei (e.g. $[\mathrm{d}\,\mu^-\,\mathrm{d}]^+$, where d is the deuteron), the structure of the ion is changed in a qualitative way — it is converted into a one-centre "compound ion" $[^{4*}\mathrm{He}\ \mu^-]^+$ owing to a two order increase in lepton mass. Energy is then released as a result of fragmentation* and the liberation of a muon (μ catalysis).

There is the possibility that conversions of this sort occur in processes involving light diatomic molecules (in particular, D_2) as they interact with positrons in the process of production of orthopositronium [o-Ps, $^{\mathrm{T}}\mathrm{Ps} \equiv {}^3(e^+e^-)_1$]. This suggestion is based primarily on the results of independent measurements which have established lifetime anomalies in o-Ps annihilation (deviations from QED), on the "isotopic anomaly" [1] and the "λ_{T}-anomaly" [2, 3].

"Positronium, the bound state of the electron and positron, is a purely leptonic state — it is effectively free of hadronic and weak-interaction effects" [2], and its annihilation is calculated with high precision in QED. Observation of the "isotopic anomaly" [1] was the basis for careful study this assertion. This relationship sets up a new perspective which merits further studies.

In this connexion there is special interest in the results on lifetime annihilation spectra of positrons (orthopositronium) in liquid and solid deuterium [4] and comparison of these results with corresponding results on protium [5]. In particular, Liu and Roberts [4] have measured the short-lived components in the time-resolved spectra: $\tau_1 = 0.83 \pm 0.03$ ns (liquid D_2, 20.4 K) and $\tau_1 = 0.74 \pm 0.03$ ns (solid D_2, 13 K). However, there are no data on a long-lived component (o-Ps). The results for H_2 are $\tau_1 = 0.92 \pm 0.04$ ns (20.4 K) and $\tau_1 = 0.80 \pm 0.03$ ns (13 K). In contrast with the D_2 case, data were reported on o-Ps ($\tau_2 = 28.6 \pm 2.3$ ns at 20.4 K and 14.6 ± 1.2 ns at 13 K [5]).

Clearly, o-Ps is formed in condensed deuterium in the same way as in condensed protium. We are thus led to ask whether o-Ps is indeed absent from the time-resolved annihilation spectra in condensed deuterium. The single corresponding study [4] has failed to answer this question unambiguously.

*In the neutron channel ^{3}He (0.82 MeV) + n (2.45 MeV), or in the tritium channel, T (1.01 MeV) + p (3.02 MeV).

2 Background of the hypothesis and the first attempt of its verification (a cumulative method of identification of products of nuclear synthesis)

If this difference between the time-resolved positron annihilation spectra in the condensed states of H_2 and D_2 is confirmed, then the absence of the o-Ps-component in liquid and solid deuterium could be explained on the basis that it is quenched by radiolysis products with net charge and spin, in a "blast hole" of charged products of nuclear synthesis which carry off a total energy of a few MeV per event. These products of radiolysis suppress the long-living component of the lifetime spectra (*quenching* of o-Ps [6]).

For an explanation and quantitative description of the orthopositronium anomalies [1–3] the hypothesis of representation of the β^+-decay of the nuclei ^{22}Na, ^{68}Ga, etc. ($\Delta J^\pi = 1^+$) as a *topological quantum transition* in a limited (macroscopic) "volume" of space-time is justified. The limited "volume" ("*defect*") of space-time, i.e. *vacuum-like state of matter* with positive Planckian mass $+M_{Pl}$, is the *long-range atom* having a full number of sites $N^{(3)} = 1.302 \times 10^{19}$. All its charges (baryon charge among them) are compensated for by a discrete scalar *C-field* (the "mirror Universe" with negative Planckian mass $-M_{Pl}$). A "defect" of space-time becomes some "background" where orthopositronium is within of macroscopic "*long-range atom nucleus*" with the number of sites $\bar{n} = 5.2780 \times 10^4$ in oscillation [7–12].

"Let there be a certain probability for disturbances in vacuum to alter its topology. If we now visualize some sort of 'handedness' such that at the entrance the particle is right-handed, and at the exit it is left-handed, then we have a certain probability for a right-left particle transition, which means that the particles have a rest mass" [13].

The aforementioned oscillations between the observable Universe and the "mirror Universe" are responsible for an additional mode of the orthopositronium annihilations

$$\text{o-Ps}\backslash\text{o-Ps}'(\text{p-Ps}') \to \gamma^\circ \backslash 2\gamma',$$

where γ° is a notoph, a massless particle with zero helicity, in addition to the properties to the photon (helicity ± 1); in interactions the notoph, as well as the photon, transfers spin 1 [14]. These oscillations can also cause an additional mass for electrons e_*^- that can result in nuclear synthesis during o-Ps formation by

$$e_\beta^+ + \left[d\,e^- e^- d\right] \to {}^3(e_\beta^+ e_*^-)_1 \left[d\,e_*^- d\right]^+ \to$$
$$\to \left[{}^{4*}\mathrm{He}\,e^-\right] \to \left[\begin{array}{c} {}^3\mathrm{He} + n \\ T + p \end{array} \right].$$

Thus, the orthopositronium anomalies (as manifestation of its connexion with the "mirror Universe") permit the formulation of a hypothesis about effective o-Ps topological mass ($\sim 200\ m_e$) and, accordingly, a two-way connexion of an electron in $[d\,e_*^- d]^+$ (owing to an exchange interaction at the moment of o-Ps formation), along with an experimental programme for studying this hypothesis [15].

Amongst the products of reaction we focus on ^{3}He, since (on the one hand) it is formed directly in the neutron channel, and (on the other) it accumulates, because of the decay $T \to {}^3\mathrm{He} + e^- + \tilde{\nu}$ from the tritium channel. The accumulation method with exposition time $t_{exp} \sim 0.32$ years and a high-sensitivity *magnetic resonant mass-spectrometer* for the analysis, ^{3}He and ^{4}He have established a *negative result* concerning the products of fragmentation of a compound ion $[{}^{4*}\mathrm{He}\ e^-]^+$ not only by the neutron channel, but also by the tritium channel [15].

However these results do not rule out the overall hypothesis which we consider: there is a possibility that nuclear synthesis involving o-Ps is cut off in the stage of formation of the "compound ion" $[{}^{4*}\mathrm{He}\ e^-]^+$, with subsequent relaxation of nuclear excitation energy (23.85 MeV) as kinetic energy of an "α-particle", as the "long-range atom" through an "atomic nucleus" can relinquish its non-recoil energy. Now there are no data on quantum energy excitation structure of the "nucleus" and "long-range atom" as a whole. Because of the disproportionately large mass of an "atom" (M_{Pl}) in comparison with the mass of an "α-particle", the latter can practically carry away all energy of excitation and formation in a final state, after delay and recombination, as follows,

$$e_\beta^+ + [d\,e^- e^- d] \to {}^3(e_\beta^+ e_*^-)_1 [d\,e_*^- d]^+ \to$$
$$\to \left[{}^{4*}\mathrm{He}\,e^-\right] \to {}^4\mathrm{He} + e^- + Q\,(23.85\,\mathrm{MeV}),$$

but part of energy can be transferred to the "lattice" of the *vacuum-like state of matter*.

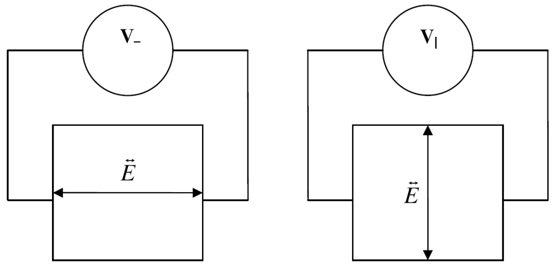

Fig. 1: V_- and $V_|$ are electric breakdown thresholds of the gas when the dc electric field is oriented horizontally and vertically respectively. A decrease in the electric breakdown threshold of deuterium (D_2) is anticipated for perpendicular orientation of electric field to gravity, under other identical conditions ($V_- < V_|$). For H_2 the electric breakdown thresholds in these measurements cannot significantly differ ($V_- \equiv V_|$). (A conventional criterion: $\vec{E} > 6.7$ kV/cm [16].)

3 The electric field opens an opportunity of direct check of a hypothesis

The latest work of the Michigan group has created a new situation for the hypothesis adduced herein. It is necessary to emphasize that the result of the last set of Michigan measurements, after introduction of a dc electric field up to $\sim$7 kV/cm in a measuring cell [16], we treat as the first observation of a connexion between gravitation and electricity [11, 12]. The introduction of an electric field in the final Michigan experiment can have other (additional) consequences to those given by authors for o-Ps thermalization [16]. According to the hypothesis, manifestation of the "isotopic anomaly" [1] and the λ_T-anomaly [2, 3] as *macroscopic quantum effects* is the generalized "displacement currents" in the final state of the topological quantum transition for nuclei ^{22}Na, ^{68}Ga, etc. The electric field probably counteracts the generalized displacement currents and has led to suppression of macroscopic quantum effects [10, 12]. The Michigan experiment [16] was set up in such a way that an electric field introduced into the experiment (it accelerates the particle beam before the target) merely suppressed the anomaly, despite the fact that the electric field helps achieve complete thermalization of orthopositronium in the measurement cell. Consequently, the anomaly, present but suppressed by the field, merely became obscured in the given experiment.

In work [12] the analysis of the mechanism of suppression of macroscopic quantum effects by an electric field is presented, from which it follows that comparative measurements of a threshold of electric breakdown in a cell with a source of positrons (^{22}Na) alternately filled by dense gases (D_2, H_2), and (for each gas) with change of orientation of an electric field (parallel and perpendicular to gravity) can be a more sensitive tool for identification of *macroscopic quantum effects* in comparison with the accumulation method [15]. At sufficiently high pressures of D_2 the activity of a source of stationary concentrations of positrons of the radiolysis products in a field $\vec{E} > 6.7$ kV/cm, the background level created by cosmic and other casual sources of radiations can be repeatedly exceeded. In these conditions the threshold of electric breakdown of a gas oriented parallel to gravity ($V_|$) will be higher than the electric breakdown threshold of gas oriented perpendicular to gravity (V_-), under other identical conditions ($V_| > V_-$).

The experiment suggested herein, with introduction of an electric field $\vec{E} > 7$ kV/cm into a measuring cell, provided that a field $\vec{E} > 6.7$ kV/cm is still under the electric breakdown threshold of the gas (see Fig. 1), is the *decisive experiment*.

Dedication

This paper is dedicated to the memory of our long-time coauthor Dr. Boris Aleksandrovich Kotov (October 8, 1938 — April 10, 2005).

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Reply to "Notes on Pioneer Anomaly Explanation by Satellite-Shift Formula of Quaternion Relativity"

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In the present article we would like to make a few comments on a recent paper by A. Yefremov in this journal [1]. It is interesting to note here that he concludes his analysis by pointing out that using full machinery of Quaternion Relativity it is possible to explain Pioneer XI anomaly with excellent agreement compared with observed data, and explain around 45% of Pioneer X anomalous acceleration. We argue that perhaps it will be necessary to consider extension of Lorentz transformation to Finsler-Berwald metric, as discussed by a number of authors in the past few years. In this regard, it would be interesting to see if the use of extended Lorentz transformation could also elucidate the long-lasting problem known as Ehrenfest paradox. Further observation is of course recommended in order to refute or verify this proposition.

1 Introduction

We are delighted to read A. Yefremov's comments on our preceding paper [3], based on his own analysis of Pioneer anomalous "apparent acceleration" [1]. His analysis made use of a method called Quaternion Relativity, which essentially is based on $\mathrm{SO}(1,2)$ form invariant quaternion square root from space-time interval rather than the interval itself [1, 2]. Nonetheless it is interesting to note here that he concludes his analysis by pointing out that using full machinery of Quaternion Relativity it is possible to explain Pioneer XI anomaly with excellent agreement compared with observed data, and explain around 45% of Pioneer X anomalous acceleration [1].

In this regard, we would like to emphasize that our preceding paper [3] was based on initial "conjecture" that in order to explain Pioneer anomaly, it would be necessary to generalize pseudo-Riemann metric of General Relativity theory into broader context, which may include Yefremov's Quaternion Relativity for instance. It is interesting to note here, however, that Yefremov's analytical method keeps use standard Lorentz transformation in the form Doppler shift effect (Eq. 6):

$$f = \frac{f'}{\sqrt{1-\left(\frac{v_D}{c}\right)^2}}\left(1-\frac{v_D}{c}\cos\beta\right). \tag{1}$$

While his method using relativistic Doppler shift a la Special Relativity is all right for such a preliminary analysis, in our opinion this method has a drawback that it uses "standard definition of Lorentz transformation" based on 2-dimensional problem of *rod-on-rail* as explained in numerous expositions of relativity theory [5]. While this method of rod-on-rail seems sufficient to elucidate why "simultaneity" is ambiguous term in physical sense, it does not take into consideration 3-angle problem in more general problem. This is why we pointed out in our preceding paper that apparently General Relativity inherits the same drawback from Special Relativity [3].

Another problem of special relativistic definition of Lorentz transformation is known as "reciprocity postulate", because in Special Relativity it is assumed that: $x \leftrightarrow x'$, $t \leftrightarrow t'$, $v \leftrightarrow -v'$ [6]. This is why Doppler shift can be derived without assuming reciprocity postulate (which may be regarded as the "third postulate" of Special Relativity) and without special relativistic argument, see [7]. Nonetheless, in our opinion, Yefremov's Quaternion Relativity is free from this "reciprocity" drawback because in his method there is difference between moving-observer and static-observer [2].

An example of implications of this drawback of 1-angle problem of Lorentz transformation is known as Ehrenfest paradox, which can be summarized as follows: "According to Special Relativity, a moving rod will exhibit apparent length-reduction. This is usually understood to be an observational effect, but if it is instead considered to be a real effect, then there is a paradox. According to Ehrenfest, the perimeter of a rotating disk is like a sequence of rods. So does the rotating disk shatter at the rim?" Similarly, after some thought Klauber concludes that "*The second relativity postulate does not appear to hold for rotating systems*" [8].

While it is not yet clear whether Quaternion-Relativity is free from this Ehrenfest paradox, we would like to point out that an alternative metric which is known to be nearest to Riemann metric is available in literature, and known as Finsler-Berwald metric. This metric has been discussed adequately by Pavlov, Asanov, Vacaru and others [9–12].

2 Extended Lorentz-transformation in Finsler-Berwald metric

It is known that Finsler-Berwald metric is subset of Finslerian metrics which is nearest to Riemannian metric [12], therefore it is possible to construct pseudo-Riemann metric based on Berwald-Moor geometry, as already shown by Pavlov [4]. The neat link between Berwald-Moor metric and Quaternion Relativity of Yefremov may also be expected because Berwald-Moor metric is also based on analytical functions of the H4 variable [4].

More interestingly, there was an attempt in recent years to extend 2d-Lorentz transformation in more general framework on H4 of Finsler-Berwald metric, which in limiting cases will yield standard Lorentz transformation [9, 10]. In this letter we will use extension of Lorentz transformation derived by Pavlov [9]. For the case when all components but one of the velocity of the new frame in the old frame coordinates along the three special directions are equal to zero, then the transition to the frame moving with velocity V_1 in the old coordinates can be expressed by the new frame as [9, p.13]:

$$\begin{pmatrix} x_0 \\ x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{bmatrix} [F] & [0] \\ [0] & [F] \end{bmatrix} = \begin{pmatrix} x'_0 \\ x'_1 \\ x'_2 \\ x'_3 \end{pmatrix} \tag{2}$$

where the transformation matrix for Finsler-Berwald metric is written as follows [9, p.13]:

$$[F] = \begin{pmatrix} \frac{1}{\sqrt{1-V_1^2}} & \frac{V_1}{\sqrt{1-V_1^2}} \\ \frac{V_1}{\sqrt{1-V_1^2}} & \frac{1}{\sqrt{1-V_1^2}} \end{pmatrix} \tag{3}$$

and

$$[0] = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}. \tag{4}$$

Or

$$x_0 = \frac{x'_0 + V x'_1}{\sqrt{1 - V_1^2}} \; x_1 = \frac{V x'_0 + x'_1}{\sqrt{1 - V_1^2}} \,, \tag{5}$$

and

$$x_2 = \frac{x'_2 + V x'_3}{\sqrt{1 - V_1^2}} \; x_3 = \frac{V x'_2 + x'_3}{\sqrt{1 - V_1^2}} . \tag{6}$$

It shall be clear that equation (5) $(x'_0, x'_1) \leftrightarrow (x_0, x_1)$ coincides with the corresponding transformation of Special Relativity, while the transformation in equation (6) differs from the corresponding transformation of Special Relativity where $x_2 = x'_2$, $x_3 = x'_3$ [9].

While we are not yet sure whether the above extension of Lorentz transformation could explain Pioneer anomaly better than recent analysis by A. Yefremov [1], at least it can be expected to see whether Finsler-Berwald metric could shed some light on the problem of Ehrenfest paradox. This proposition, however, deserves further theoretical considerations.

In order to provide an illustration on how the transformation keeps the Finslerian metric invariant, we can use Maple algorithm presented by Asanov [10, p.29]:

```
> c1:=cos(tau);c2:=cos(psi);c3:=cos(phi);
> u1:=sin(tau);u2:=sin(psi);u3:=sin(phi);
> l1:=c2*c3−c1*u2*u3;l2:=−c2*u3−c1*u2*c3;l3:=u1*u2;
> m1:=u2*c3+c1*c2*u3;m2:=−u2*u3+c1*c2*c3;m3:=−u1*c2;
> n1:=u1*u3; u1*c3; c1;
> F1:=(e1)^((l1+m1+n1+l2+m2+n2+l3+m3+n3+1)/4)*
(e2)^((−l1−m1−n1+l2+m2+n2−l3−m3−n3+1)/4)*
(e3)^((l1+m1+n1−l2−m2−n2−l3−m3−n3+1)/4)*
(e4)^((−l1−m1−n1−l2−m2−n2+l3+m3+n3+1)/4):
> F2:=(e1)^((−l1+m1−n1−l2+m2−n2−l3+m3−n3+1)/4)*
(e2)^((l1−m1+n1−l2+m2−n2+l3−m3+n3+1)/4)*
(e3)^((−l1+m1−n1+l2−m2+n2+l3−m3+n3+1)/4)*
(e4)^((l1−m1+n1+l2−m2+n2−l3+m3−n3+1)/4):
> F3:=(e1)^((l1−m1−n1+l2−m2−n2+l3−m3−n3+1)/4)*
(e2)^((−l1+m1+n1+l2−m2−n2−l3+m3+n3+1)/4)*
(e3)^((l1−m1−n1−l2+m2+n2−l3+m3+n3+1)/4)*
(e4)^((−l1+m1+n1−l2+m2+n2+l3−m3−n3+1)/4):
> F4:=(e1)^((−l1−m1+n1−l2−m2+n2−l3−m3+n3+1)/4)*
(e2)^((l1+m1−n1−l2−m2+n2+l3+m3−n3+1)/4)*
(e3)^((−l1−m1+n1+l2+m2−n2+l3+m3−n3+1)/4)*
(e4)^((l1+m1−n1+l2+m2−n2−l3−m3+n3+1)/4):
> a:=array(1..4,1..4):
for i from 1 to 4
do
for j from 1 to 4
do
a[i,j]:=diff(F||i,e||j);
end do:
end do:
> b:=array(1..4,1..4):
for i from 1 to 4
do
for j from 1 to 4
do
b[i,j]:=simplify(add(1/F||k*diff(a[k,i],e||j),k=1..4),symbolic);
end do:
end do:
> print(b);
```

The result is as follows:

$$\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} .$$

This result showing that all the entries of the matrix are zeroes support the argument that the metricity condition is true [10].

3 Concluding remarks

In the present paper we noted that it is possible to generalise standard Lorentz transformation into H4 framework of Finsler-Berwald metric. It could be expected that this extended Lorentz transformation could shed some light not only to Pioneer anomaly, but perhaps also to the long-lasting problem of Ehrenfest paradox which is also problematic in General Relativity theory, or by quoting Einstein himself:

> "...Thus all our previous conclusions based on general relativity would appear to be called in question. In reality we must make a subtle detour in order to be able to apply the postulate of general relativity exactly" [5].

This reply is not intended to say that Yefremov's preliminary analysis is not in the right direction, instead we only highlight a possible way to improve his results (via extending Lorentz transformation). Furthermore, it also does not mean to say that Finsler-Berwald metric could predict better than Quaternion Relativity. Nonetheless, further observation is of course recommended in order to refute or verify this proposition.

Acknowledgment

The writers would like to thank to Profs. C. Castro for citing the Vacaru *et al.*'s book [11]. We are also grateful for discussion with Profs. A. Yefremov, G. Asanov and Z. Szabo.

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Comment on "Single Photon Experiments and Quantum Complementarity" by D. Georgiev

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The paper "Single Photon Experiments and Quantum Complementarity" by Georgiev misrepresents my position on the Afshar "which path/interference" debate.

D. Georgiev has recently published a paper [1] in which he argues that my interpretation [2] of a "complementarity" experiment based on Afshar's original suggestion [3] is incoherent and wrong. Unfortunately his interpretation of my model distorted what I say.

The Afshar experiment is one in which it is claimed one can both determine both which path a photon has followed and that the photon self interfered in one and same experiment, violating Bohr's complementarity principle, that complementary aspects of a system cannot simultaneously be measured. I have suggested a more stark experiment than Afshar's which throws the issues into greater relief, one whose setup Georgiev describes well in his paper.

However, he then implies that I hold certain positions about the interpretation of the experiment, interpretations which I neither hold not are contained in my description.

Referring to Georgiev's diagram, I demonstrate that **if** the photon is known to have traveled down arm 1 of the interferometer (for example by blocking arm 2, or by any other means, then the detector D1 will always register the photon. If the photon is known to have gone down arm 2, then detector D2 always clicks. The crucial question is what happens if the photon is in an arbitrary state. This raises a variety of questions, including the question as to whether one can ever infer anything about a system being measured from the outcomes reported on the measuring instrument. One could of course take the position of no. That the readings on measurement instruments tell one only about that measuring instrument and cannot be used to infer anything about the system being measured. While a defensible position, it is also one which would make experimental physics impossible. My position follows that of von Neuman, that one can make inferences from the reading on the measurement instruments to the system being measured. IF there is a 100% correlation between the apparatus outcome and the system when the system is known to be in a certain state, and if orthogonal states for the system lead to different outcomes in the apparatus, then one can make inferences from the outcome of the apparatus to the attribute of the system. In this case, the 100% correlation between which detector registers the photon to the known path the photon followed (1 or 2) allows one to infer that IF the detector D1 registers the photon, then that photon has the property that it followed path 1. This is true no matter what the state of the photon was — pure or mixed or something else. Readings on apparatus, if properly designed DO allow one to infer values for attributes of the system at earlier time.

Note the key point I made in my paper was that **if** one places an absorber into path 5 or 6, then even if those absorbers do not ever actually absorb any photons, they do destroy that correlation between the reading on the detectors and the the path, 1 or 2, the photon follows. Because in this case, if we know that the photon was on path 1, either detector D1 or D2 will register, with 50% probability or if the photon was detected by detector D1, the photon could have come from either path 1 or 2. One cannot any longer infer from the apparatus (the detectors) which path of the photon took, precisely because one was also trying to determine in the two paths interfered. The change in the experimental situation destroys the critical correlation required to make those inferences.

Georgiev then claims to prove that such an interpretation is incoherent and disagrees with the mathematics. He bases this on his equations 7 and 8 in which he ascribes a state to the photon both passing along arm 1 or 2 and arm 5 or 6. In no conventional quantum formalism do such states exist. Certainly amplitudes for the particle traveling along both path 1 and 5, say, exist, but amplitudes are just complex numbers. They are not states. And complex numbers can be added and subtracted no matter where they came from.

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Exact Mapping of Quantum Waves between Unruh's and Afshar's Setup (Reply to W. Unruh)

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In a recent letter, Unruh argued that I have misrepresented his position and I have "*put words into his mouth*" which distort Unruh's original analysis of Unruh's setup. Unfortunately such a complaint is ungrounded. I have presented a mathematical argument that Unruh's which way claim for the discussed setup is equivalent to the claim for a mixed density matrix of the experiment. This is a mathematical proof, and has nothing to do with misrepresentation. Unruh clearly accepts the existence of the interference pattern at paths 5 and 6, accepts that the setup is described by pure state density matrix, and at the same time insists on existing which way bijection, therefore his position is provably mathematically inconsistent.

1 Direct calculation of detector states

Unruh in [6, 7] clearly has accepted the existence of unmeasured destructive interference at path 5 (pure state density matrix) plus a direct which way claim stating that $|\psi_1\rangle$ and $|\psi_2\rangle$ are respectively eigenstates of the detectors $\mathfrak{D}_1$ and $\mathfrak{D}_2$, thus it is easy for one to show that Unruh's analysis is mathematically inconsistent [2]. Despite of the fact that the mathematical analysis in my previous paper is rigorous, it was based on retrospective discussion deciding which waves shall annihilate, and which shall remain to be squared according to Born's rule. The choice for such a purely mathematical discussion was done in order to provide insight *why* Unruh's confusion arises. In this comment I will present concise physical description of the evolution of the photon based on direct forward-in-time calculation of Unruh's setup described in detail in [2], and will spot several troublesome claims made by Unruh, which appear to be severe mathematical misunderstandings.

For a coherent setup the quantum state in Unruh's interferometer after exit of beamsplitter 2 (BS2) is $|\Psi(t_1)\rangle = -1|\psi_6\rangle$, where $|\psi_6\rangle$ denotes the wavefunction evolving along path 6.* After reflection at mirror 3 (M3) the state evolves into $|\Psi(t_2)\rangle = -\imath|\psi_6\rangle$, which meets BS3 and splits into coherent superposition of two parts each going to one of the detectors

$$|\Psi(t_3)\rangle = \left(\frac{1}{\sqrt{2}} - \frac{1}{\sqrt{2}}\imath\right)|\psi_6\rangle = \frac{1}{\sqrt{2}}|\mathfrak{D}_1\rangle - \frac{1}{\sqrt{2}}\imath|\mathfrak{D}_2\rangle \quad (1)$$

from which follows that $|\mathfrak{D}_1\rangle = |\mathfrak{D}_2\rangle = |\psi_6\rangle$. Since $|\psi_6\rangle = \frac{1}{2}(|\psi_1\rangle + |\psi_2\rangle)$ it is obvious that $|\psi_1\rangle$ and $|\psi_2\rangle$ are *not* eigenstates of the detectors $\mathfrak{D}_1$ and $\mathfrak{D}_2$. That is why there is no which way information in coherent version of Unruh's setup. To suggest that the BS3 can selectively only reflect or only transmit the components $|\psi_1\rangle$ and $|\psi_2\rangle$ in a fashion preserving the which way correspondence is *mathematically equivalent* to detect photons at path 6, and then determine just a single path 1 or 2 along which the photon has arrived. Since it is impossible for one to distinguish the $|\psi_1\rangle$ component from the $|\psi_2\rangle$ component of a photon detected at path 6 it is perfectly clear that the BS3 cannot distinguish these components either, so standard QM prediction is that BS3 will "see" photon coming at path 6 but BS3 will not make any difference for $|\psi_1\rangle$ or $|\psi_2\rangle$ component of the photon state. BS3 will reflect both $|\psi_1\rangle$ and $|\psi_2\rangle$ to both detectors. The evolution of the state $-\imath|\psi_6\rangle$ into a coherent superposition going to both detectors providing no which way information is straightforward and can be characterized as "back-of-an-envelope calculation".†

Now let us investigate why if one prevents the interference along path 5 by converting the setup into a mixed one, the which way information will be preserved and the states $|\psi_1\rangle$ and $|\psi_2\rangle$ *will be* eigenstates of the corresponding detectors. First, one must keep in mind how the quantum entanglements (correlations) work in QM — due to the fact the photon wavefunction is entangled with the state of external system it is possible if one investigates only the reduced density matrix of the photon to see mixed state with all off-diagonal elements being zeroes, hence no interference effects manifested. This is the essence of Zeh's decoherence theory which does not violate Schrödinger equation and one

*Here explictly should be noted that $|\psi_6\rangle$ is not just eigenstate of the position operator describing location at path 6, it is a wavefunction describing the photon state including its energy (wavelength), position, momentum, etc., that evolves in time and which may be represented as a vector (ket) in Hilbert space. As we speak about arbitrary photon with arbitrary energy, etc., the definition of the vector $|\psi_6\rangle$ is left flexible with the comprehension that it must describe fully the characteristics of the real photon. Also $|\psi_6\rangle$ is an unit vector, and as easily can be seen it must be multiplied by -1 in order for one to get the real state of the qubit at path 6.

†This expression was used by Prof. Tabish Qureshi (Jamia Millia Islamia, New Delhi, India) to describe how in just a few lines one can disprove Afshar's analysis and the calculation can be performed on the back side of an envelope for letters.

ends up with states that are not true classical mixtures, but have the same mathematical description satisfying the XOR gate. Thus let us put vertical polarizator **V** on path 1 and horizontal polarizator **H** on path 2. The state after BS2 will have non-zero component at path 5

$$|\Psi(t_1)\rangle = \left[-\frac{1}{2}\imath|\psi_1\rangle|\mathrm{V}\rangle + \frac{1}{2}\imath|\psi_2\rangle|\mathrm{H}\rangle\right] + \\ + \left[-\frac{1}{2}|\psi_1\rangle|\mathrm{V}\rangle - \frac{1}{2}|\psi_2\rangle|\mathrm{H}\rangle\right]. \tag{2}$$

Now as both wavefunctions ψ_1 and ψ_2 are orthogonal and distinguishable because of spatial separation (no overlap) in the interferometer arms 1 and 2, and because they get entangled with orthogonal states of the two different polarizators **V** and **H**, in the future spatial overlapping of the wavefunctions ψ_1 and ψ_2 cannot convert them into non-orthogonal states. Due to entanglement with polarizators the photon state is such that as if for ψ_1 the wavefunction ψ_2 does not exist, hence ψ_1 cannot overlap with ψ_2, and the state will be ψ_1XORψ_2.* At the detectors due to destructive quantum interference the ψ_2 waves will self-annihilate at $\mathfrak{D}_1$ and ψ_1 waves will self-annihilate at $\mathfrak{D}_2$. Thus $|\psi_1\rangle|\mathrm{V}\rangle$ and $|\psi_2\rangle|\mathrm{H}\rangle$ *will be* eigenstates of the corresponding detectors $\mathfrak{D}_1$ and $\mathfrak{D}_2$ (see details in [2]). This which way information is only existent because of the existent which way label which is the mixed state of photon polarization due to entanglements with the polarizators. In Unruh's single path setups the mixture of the photon states is result of obstacles on one of the interferometer paths, and then taking fictitious statistical average i.e. photons from the two alternative setups run in two distinguishable time intervals t_1 vs t_2. So in the classical mixture of two single path trials investigated by Unruh the time intervals t_1 and t_2 have the equivalent function of $|\mathrm{V}\rangle$ and $|\mathrm{H}\rangle$ entanglements. In order to complete the analogy one may explicitly write entanglements with orthogonal kets $|t_1\rangle$ and $|t_2\rangle$ describing the *interferometer quantum state* with obstacles on one of the two paths 1 or 2. Thus actually in the classical mixture discussed by Unruh it is $|\psi_1\rangle|t_1\rangle$ and $|\psi_2\rangle|t_2\rangle$ that are the eigenstates of the detectors. Destroying the mixture leads to loss of the which way information at the detectors.

Where was the essential step in the mixed setup that allowed us to recover the which way information? It was exactly the nonzero value of path 5. If in a coherent setup one allows for a state $0|\psi_5\rangle$ it is obvious that the vector $|\psi_5\rangle$ cannot be recovered without division to *zero*. Recovering of the which way information requires components included in the vector $|\psi_5\rangle$, thus one will be mathematically inconsistent if keeps the which way claim, and also claims that the state at path 5 is $0|\psi_5\rangle$ i.e. from that moment $|\psi_5\rangle$ is erased. It is obvious that in any QM calculation one can write the real state as a sum of infinite number of such terms of arbitrary vector states multiplied by *zero* without changing anything e.g. $|\Psi\rangle = |\Psi\rangle + 0|\Lambda\rangle + \dots + 0|\Theta\rangle$. However all these *zeroed* components do not have physical significance.

And last but not least, it is clear that puting obstacle on place where the quantum amplitudes are expected to be *zero* does not change the mathematical description of the setup. Formally one may think as if having *Renninger negative-result experiment* [4] with the special case of measuring at place where the probability is *zero*. This is the only QM measurement that does not collapse the wavefunction of the setup! Analogously one may put obstacles in the space outside of the Unruh's interferometer. As the photon wavefunction is *zero* outside the interferometer it is naive one to expect that the photon wavefunction inside the interferometer is collapsed by the obstacles located around the interferometer. So puting obstacle or not, at place where the quantum amplitudes are *zero*, does not change the mathematical description. As this is always true, Unruh's idea that having obstacle or not at the negative interference area at path 5 will change the final conclusions of the which way information is wrong. As we have defined the which way information as provable bijection, it is unserious for one to believe that from a difference that has no effect on photon's wavefunction and does not change the mathematical description, one may change a mathematical proof of existent bijection.

2 Which way information as provable bijection

Now we will show that the naive statement that which way information and quantum interference are incompatible with each other is generally *false*. First one must define the which way information as a *provable bijection* between at least two distinguishable wavefunctions and two observables. Alternatively no which way information will be *disprovable bijection* i.e. the bijection is provably *false*. Then one can only say that *if* the bijection is *true* then quantum *cross-interference* of the two wavefunctions did not occur, yet *self-interference* is always possible! This was explicitly formulated in [2] however in the text bellow we discuss the idea in depth with the proposed Georgiev's four-slit experiment.

Let us us have four equally spaced identical slits A, B, C, D, and let us detect the interference pattern of photon at the *far-field Fraunhofer limit*. In case of coherent setup one will have coherent wavefunction $\Phi \equiv \Psi_A + \Psi_B + \Psi_C + \Psi_D$ and will observe a single four-slit interference $P = |\Psi_A + \Psi_B + \Psi_C + \Psi_D|^2$. This is a no which way distribution as far as we know that the photon amplitudes have passed through all four slits at once in quantum superposition.

Now let us put **V** polarizators on slits A and B, and **H** polarizators on slits C and D. There will be no *cross-interference* between the wavefunctions $\Phi_1 \equiv \Psi_A + \Psi_B$ and $\Phi_2 \equiv \Psi_C + \Psi_D$ and the observed intensity distribution will be mixed one $\mathcal{P} = |\Psi_A + \Psi_B|^2 + |\Psi_C + \Psi_D|^2$. In this case one can establish provable bijection $\Phi_1 \to P_1 \equiv |\Psi_A + \Psi_B|^2$,

*If however one erases the polarization the spatial overlap of the two waves will manifest interference and will erase the which way information.

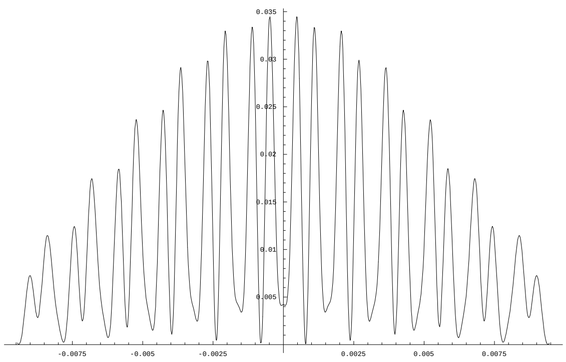

Fig. 1: The four slit interference pattern $P = |\Psi_A + \Psi_B + \Psi_C + \Psi_D|^2$ of non-polarized or identically polarized photons.

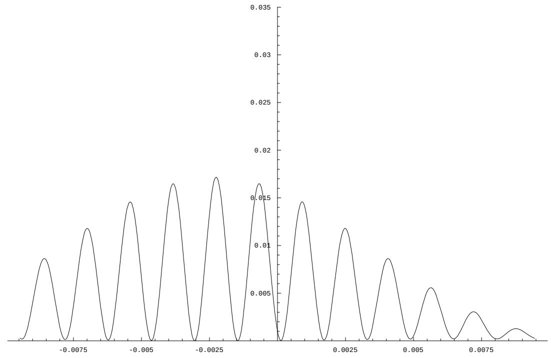

Fig. 2: Shifted to the left $P_1 = |\Psi_A + \Psi_B|^2$ double-slit interference pattern of vertically polarized photons.

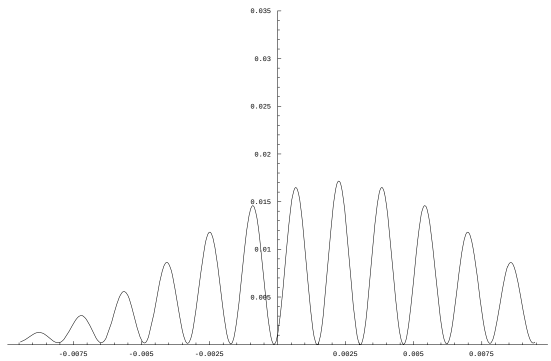

Fig. 3: Shifted to the right $P_2 = |\Psi_C + \Psi_D|^2$ double-slit interference pattern of horizontally polarized photons.

$\Phi_2 \to P_2 \equiv |\Psi_C + \Psi_D|^2$. Thus there is which way information $\Phi_1 \to P_1$, $\Phi_2 \to P_2$ only because there is no cross-interference between Φ_1 and Φ_2. The self-interferences of Φ_1 and Φ_2 are always there e.g. the cross-interference between Ψ_A and Ψ_B does not allows us to further prove existent bijection in which only slit A wavefunction, or only slit B wavefunction participates. In order to illustrate the discussion we have performed numerical plotting with *Wolfram's Mathematica 5.2* for photons with wavelength $\lambda = 850$nm, slit width $s = 0.25$mm, interslit distance $d = 2$mm, at the Fraunhofer limit $z = 4.2$ m behind the four slits. Results are presented in Figures 1–3.

This section on the which way information as existent provable bijection was added for clarity. From the presented details it does *not* follow that Bohr's complementarity principle is wrong, we have just explicitly reformulated the principle providing strict definitions for *which way claims* as *bijections*, and have clarified the useful terms *self-interference* and *cross-interference*. If one investigates existent bijection then self-interference is always there, only certain cross-interferences are ruled out.

3 Quantum states as vectors

In this section we point out that QM can be approached in three ways. One way is to use wave equations with the prototype being the *Schrödinger equation*. One may write down a wave function $\Psi(x, t)$ that evolves both in space and time, where x is defined in $\mathbb{R}^3$. It is clear that the *history* of such mathematical function can be "traced" in time t, because the very defining of the wavefunction should be done by specifying its temporal evolution. Every wavefunction can be represented as a vector (ket) in Hilbert space. This is just second equivalent formulation, and changes nothing to the above definition. As the wavefunction evolves in time, it is clear that the vector representing the function will evolve in time too. It is the wavefunction that is referred to as *quantum state*, and it is the equivalent vector representing the wavefunction that is called *state vector*. Third way to represent the quantum state is with the use of *density matrices*. In the previous work [2] we have used all three representations in order to provide more clear picture of Unruh's setup.

Namely, we have shown that the different wavefunctions if they manifest cross-interference are no more described by orthogonal vectors in Hilbert space. What is more the wavefunctions were "traced" in time in order for one to prove possible bijections. Surprisingly Unruh makes the following claim:

> "*Certainly amplitudes for the particle travelling along both path 1 and 5, say, exist, but amplitudes are just complex numbers. They are not states. And complex numbers can be added and subtracted no matter where they came from.*"

Such a misunderstanding of mathematical notation is not tolerable. As written in Eqs. 7–8 in [2] the usage of Dirac's ket notation is clear. All kets denote vectors (wavefunctions), hence all these are quantum states, and nowhere I have discussed only the quantum amplitude itself.

First, one should be aware that all kets are time dependent, as for example instead of writing $|\psi_1(t_1)\rangle$, $|\psi_1(t_2)\rangle$, $|\psi_1(t_3)\rangle, \cdots$ the notation was concisely written as $|\psi_1\rangle$ with the understanding that the state is a function of time. Even for two different points along the same interferometer arm, the spread of the laser beam (or the single photon wavepacket) is different, yet this time dependence should be kept in mind without need for explicitly stating it. It is the time dependence of the state vectors that has been overlooked by Unruh. If one rejects the possibility to "trace" the history of the discussed wavefunctions in time, then he must accept the bizarre position that it is meaningless for one to speak about bijections and which way correspondences at first place.

Another target of Unruh's comment is the reality of the states $|\psi_{15}\rangle$, $|\psi_{16}\rangle$, $|\psi_{25}\rangle$, $|\psi_{26}\rangle$ in Eqs. 7–8 in [2].

> "[*Georgiev in*] *his equations 7 and 8 ascribes a state to the photon both passing along arm 1 or 2 and arm 5 or 6. In no conventional quantum formalism do such states exist.*"

Unfortunately this is wrong. Mathematically one can always represent a wavefunction as a sum of suitably defined functions. As it was clearly stated in [2] e.g. the state $|\psi_{15}\rangle$ is a wavefunction (vector, and not a scalar as erroneously argued by Unruh) which is branch of the wavefunction ψ_1 that evolves at arm 5. Therefore the mathematical definition is rigorous $\psi_1 = \alpha(t)(\psi_{15} + \psi_{16})$. One may analitically continue both functions ψ_{15} and ψ_{16} along path 1 as well, in this case the two functions are indistinguishable for times before BS2 with $\alpha = \frac{1}{2}$, while after BS2 the wavefunctions become distinguishable with $\alpha = \frac{1}{\sqrt{2}}$. The time dependence of $\alpha(t)$ is because the orthogonality of the two states is function of time. The usage of the same Greek letter with different numerical index as a *name* of a new function is standard mathematical practice in order to keep minimum the numer of various symbols used. The fact that the vector $|\psi_{15}\rangle$ is not orthogonal with the vector $|\psi_{25}\rangle$ in the coherent version of Unruh's setup is not a valid argument that it is not a valid quantum state. Mathematically it is well defined and whether it can be observed directly is irrelevant. Analogously, at path 6 the wavefunctions ψ_1 and ψ_2 are indistinguishable however mathematically they are still valid quantum states. Indistinguishability of states does not mean their non-existence as argued by Unruh. Indeed exactly because the two quantum functions $|\psi_{15}\rangle$ and $|\psi_{25}\rangle$ are defined in different way and have different time history, one may make them orthogonal by physical means. Simply putting obstacle at path 2, and then registering photon at path 5 one observes photons with intensity distribution $P_{15} = |\psi_{15}|^2$ which are solely contributed by ψ_{15}. And each photon only manifests "*passing along arm 1 and arm 5*". The other method to create mixed state where one can have bijective association of observables to each of the states $|\psi_{15}\rangle$, $|\psi_{16}\rangle$, $|\psi_{25}\rangle$, $|\psi_{26}\rangle$ is to put different polarizators **V** and **H** on paths 1 and 2, and then detect photons at paths 5 and 6. Due to polarizator entanglements there will be four observables and provable bijection $\psi_{15} \to P_{15}$, $\psi_{16} \to P_{16}$, $\psi_{25} \to P_{25}$, $\psi_{26} \to P_{26}$, where each probability distribution P is defined by the corresponding wavefunction squared and polarization of the photon dependent on the passage either through path 1 or path 2.

If Unruh's argument were true then it obviously can be applied to Unruh's own analysis, disproving the reality of the states $|\psi_1\rangle$ and $|\psi_2\rangle$ after BS2. As noted earlier, in the mixed state discussed by Unruh the state of the photon is either $|\psi_1\rangle|t_1\rangle$ or $|\psi_2\rangle|t_2\rangle$, where by $|t_1\rangle$ and $|t_2\rangle$ we denote two different distinguishable states of the Unruh's interferometer one with obstacle at path 2, and one with obstacle at path 1. It is exactly these entanglements with the external system being the interferometer itself and the obstacles that make the states $|\psi_1\rangle$ and $|\psi_2\rangle$ orthogonal at the detectors. If Unruh's logic were correct then removing the obstacles and making the two states not orthogonal at path 6 should be interpreted as non-existence for the two states. Fortunately, we have shown that Unruh's thesis is incorrect as is based on misunderstanding the difference between vector and scalar in the ket notation. All mentioned wavefunctions in [2] are well-defined mathematically and they are valid quantum states, irrespective of whether they are orthogonal with other states or not.

4 Classical language and complementarity

Unruh's confusion concerning the reality of quantum states, is grounded on some early *antirealist* misunderstandings of QM formalism. Still in some QM textbooks one might see expressions such as "*if the position of a qubit is precisely measured the momentum is largely unknown*", or "*if in the double slit setup a photon is detected at the Fraunhofer limit one will observe interference pattern but will not know which slit the photon has passed*". Such expressions are based on simple logical error — knowledge that "*the photon has not passed either only through slit 1, or only through slit 2*" is *not* mathematically equivalent to "*lack of knowledge which slit the photon has passed*".

Let us discuss a statistical mixture of two single slit experiments with shutter on one of the slits. What knowledge do we have? Certainly this is XOR knowledge, which means either one slit, or the other one, but not both! The truth-table was given in Table 1 in [2]. It is clear that exactly one of the statements "*passage through slit 1*" or "*passage through slit 2*" is *true*.

Now investigate the logical negation of the XOR gate. This essentially describes two possibilities. The first one is trivial with both slits *closed*. The photon does not pass through any slit, so no detection will occur at the Fraunhofer limit. A photon passed through slit 1 will be indistinguishable from photon passed through slit 2, but this is *vacuously true*. Simply no such photons exist! Much more interesting is however the coherent setup in which both slits are open. Logically one proves that the photon has passed through both slits at once. This is the essence of the quantum superposition and is described by AND logical gate. The statements "*passage through slit 1*" and "*passage through slit 2*" are simultaneously *true*, and it is ruled out that only one of them is true but not the other. Therefore the *antirealist* position based on classical physical intuition, and/or classical langauge is erroneous when it comes to describe superposed state. The logical negation (NOT gate) of the XOR gate i.e. the XOR gate is *false*, is wrongly interpreted as "*lack of knowledge on the slit passage*" i.e. XOR gate possibly might be *true* or might be *false*. As this lack of knowledge is contradicting the QM formalism one runs directly into inconsistency with the theory.

Let us now see the implications for Unruh's objection e.g. against the ψ_{15} state. As in a coherent setup this state is superposed with the ψ_{25} state along path 5, Unruh argues that they are both nonexistent. This conclusion is *non sequitur*, because the quantum superposition is described by AND logical gate and this means that ψ_{15} and ψ_{25} are both true, hence existent states. Unruh relies on von Neumann formulation of QM, which is *antirealist* one, and rejects to accept the reality of quantum superposed states. This is untenable position because the antirealist vision interpreted as lack of precise knowledge of one of two non-commuting observables is mathematically inconsistent with the underlying mathematical formalism. It exactly the opposite — if one knows precisely the spatial region of the localization of qubit (having XOR knowledge ruling out other possible localizations) then mathematically it will follow that the momentum will be spread widely amongst numerous possible values (hence having AND knowledge). What is the reality of the AND state is outside the scope of the present article and depends on the interpretation - in MWI the superposed states reside in different Universes, in Penrose's OR model the quantum coherent state resides in a single Universe with superposed space-time curvatures, etc.

From the preceding discussion follows that expressions as "*which way information*" and "*no which way information*" are just *names* and have precise mathematical definitions as provable bijection b, and respectively disprovable bijection $\neg b$. Also we have logically proved that non-commuting observables are always existent and well-defined mathematically. However in contrast with classical intuition necessarily at least one of the two non-commuting observables should be described by AND gate, hence being quantum superposed.

5 Qureshi's waves mapped onto Georgiev's waves

One of the major differences between works of Georgiev [2] and Qureshi [4] is that in our previous paper we have introduced explicitly the idea of XOR and AND states in QM, and we have explicitly formulated the need of provable bijection. Otherwise Qureshi's argument is identical to the presented here forward-in-time calculation. Yet for the sake of clarity, we will provide one-to-one mapping of *Qureshi's waves for Afshar's setup* with *Georgiev's waves for Unruh's setup*. This one-to-one mapping is mathematically clear evidence for existence of the quantum waves (states) described by Georgiev in [2] and leave no other alternative but one in which Unruh must confess his confusion in the complementarity debate.

As shown in [2] in retrospective discussion on wave annihilation, there will be eight waves that shall interfere. This is purely mathematical method, because mathematical truth is atemporal, and as explained before one either chooses self-interference of ψ_1 and self-interference of ψ_2 at detectors, or chooses destructive cross-interference between ψ_1 and ψ_2 at earlier times (path 5). Here we will show that the canceled sinh terms in Qureshi's calculation provide four more waves that go to both detectors and that one-to-one mapping exists with Georgiev's waves.

Let us denote all eight waves in Georgiev's description of Unruh's setup with ψ_{151}, ψ_{152}, ψ_{161}, ψ_{162}, ψ_{251}, ψ_{252}, ψ_{261}, ψ_{262}. As these are only *names*, the precise meaning for each one should be explicitly defined e.g. ψ_{151} is wavefunction whose history traced in time is passage along path 1, then passage along path 5, and ending at detector 1. Definitions for rest of the waves is analogous.

Now let us write again the Qureshi's equation for Afshar's setup

$$\Psi(y,t) = aC(t)\,e^{-\frac{y^2+y_0^2}{\Omega(t)}}\left[\cosh\frac{2yy_0}{\Omega(t)} + \sinh\frac{2yy_0}{\Omega(t)}\right] + \\ + bC(t)\,e^{-\frac{y^2+y_0^2}{\Omega(t)}}\left[\cosh\frac{2yy_0}{\Omega(t)} - \sinh\frac{2yy_0}{\Omega(t)}\right]$$

where $C(t) = \frac{1}{(\pi/2)^{1/4}\sqrt{\epsilon+2\imath\hbar t/m\epsilon}}$, $\Omega(t) = \epsilon^2 + \frac{2\imath\hbar t}{m}$, a is the amplitude contribution from pinhole 1, b is the amplitude contribution from pinhole 2, ϵ is the width of the wave-packets, $2y_0$ is the slit separation. Qureshi's analysis continues directly with annihilation of four of the waves contributed by the sinh terms i.e. for Afshar's setup $a = b = \frac{1}{\sqrt{2}}$ so the sinh terms cancel out at the dark fringes. What is left at the bright fringes are the cosh terms, which can be expanded as a sum of exponential functions, namely $\cosh x = = \frac{1}{2}\left(e^x + e^{-x}\right)$, and after simplification we arrive at*:

$$\Psi(y,t) = \frac{1}{2}\,aC(t)\left[e^{-\frac{(y-y_0)^2}{\Omega(t)}} + e^{-\frac{(y+y_0)^2}{\Omega(t)}}\right] + \\ + \frac{1}{2}\,bC(t)\left[e^{-\frac{(y-y_0)^2}{\Omega(t)}} + e^{-\frac{(y+y_0)^2}{\Omega(t)}}\right].$$

If a lens is used after the cross-interference has ocurred to take the $e^{-\frac{(y-y_0)^2}{\Omega(t)}}$ part to detector 1, and the part $e^{-\frac{(y+y_0)^2}{\Omega(t)}}$ to detector 2, one easily sees that the amplitudes from each slit evolve into a superposition of two *identical parts* that go to both detectors. The waves that shall be responsible for which way information in *mixed setups* and make possible the bijection $a \to \mathfrak{D}_1$, $b \to \mathfrak{D}_2$ are hidden in the erased sinh

*The following equation actually is the intended Eq. 10 in [2], where unfortunately *typesetting error* occurred.

terms. Taking into account that $\sinh x = \frac{1}{2}\left(e^{x} - e^{-x}\right)$, one may recover the four zeroed sinh components in the form:

$$0 = \frac{1}{2}\, aC(t) \left[e^{-\frac{(y-y_0)^2}{\Omega(t)}} - e^{-\frac{(y+y_0)^2}{\Omega(t)}} \right] + \\ + \frac{1}{2}\, bC(t) \left[-e^{-\frac{(y-y_0)^2}{\Omega(t)}} + e^{-\frac{(y+y_0)^2}{\Omega(t)}} \right].$$

If the eight interfering Qureshi's waves are denoted with Q, where Q_{1-4} arise from the cosh terms and Q_{5-8} arise from the sinh terms, then the one-to-one mapping with the eight Georgiev's waves is

$$Q_1 \equiv \frac{1}{2}\, aC(t)\, e^{-\frac{(y-y_0)^2}{\Omega(t)}} \to \psi_{161} \tag{3}$$

$$Q_2 \equiv \frac{1}{2}\, aC(t)\, e^{-\frac{(y+y_0)^2}{\Omega(t)}} \to \psi_{162} \tag{4}$$

$$Q_3 \equiv \frac{1}{2}\, bC(t)\, e^{-\frac{(y-y_0)^2}{\Omega(t)}} \to \psi_{261} \tag{5}$$

$$Q_4 \equiv \frac{1}{2}\, bC(t)\, e^{-\frac{(y+y_0)^2}{\Omega(t)}} \to \psi_{262} \tag{6}$$

$$Q_5 \equiv \frac{1}{2}\, aC(t)\, e^{-\frac{(y-y_0)^2}{\Omega(t)}} \to \psi_{151} \tag{7}$$

$$Q_6 \equiv -\frac{1}{2}\, aC(t)\, e^{-\frac{(y+y_0)^2}{\Omega(t)}} \to \psi_{152} \tag{8}$$

$$Q_7 \equiv -\frac{1}{2}\, bC(t)\, e^{-\frac{(y-y_0)^2}{\Omega(t)}} \to \psi_{251} \tag{9}$$

$$Q_8 \equiv \frac{1}{2}\, bC(t)\, e^{-\frac{(y+y_0)^2}{\Omega(t)}} \to \psi_{252} \tag{10}$$

To our knowledge this is the first exact one-to-one mapping between Unruh's setup and Afshar's setup, all previous discussions were much more general and based on analogy [2, 6]. Now one can explicitly verify that a and b terms in Qureshi's calculation have the same meaning as path 1 and path 2 in Unruh's setup; sinh and cosh terms have the meaning of the path 5 and path 6, and $e^{-\frac{(y-y_0)^2}{\Omega(t)}}$ and $e^{-\frac{(y+y_0)^2}{\Omega(t)}}$ terms have the meaning of detection at $\mathfrak{D}_1$ or $\mathfrak{D}_2$. The provided exact mapping between Qureshi's and Georgiev's work is clear evidence that Unruh's complaint for Georgiev's waves not being valid quantum states is invalid. None of the proposed by Georgiev states is being *zero*. Only couples of Georgiev's states can be collectively zeroed, but which members will enter in the zeroed couples depends on the density matrix of the setup. And this is just the complementarity in disguise.

6 Conclusions

In recent years there has been heated debate whether complementarity is more fundamental than the uncertainty principle [5, 8], which ended with conclusion that complementarity is enforced by quantum entanglements and not by uncertainty principle itself [1]. Indeed the analysis of the proposed here Georgiev's four-slit experiment, as well as the analysis of Unruh's and Afshar's setups, show that which way claims defined as provable bijections are just another mathematical expression of the underlying density matrix of the setup, and as discussed earlier diagonalized mixed density matrices in standard Quantum Mechanics are possible only if one considers quantum entanglements in the context of Zeh's decoherence theory [9].

Unruh's error is that he uses results from mixed state setup to infer which way correspondence in coherent setup, overlooking the fact that bijections must be mathematically proved. Therefore it is not necessary for one to measure the interference in order to destroy the which way claim, it is sufficient only to *know* the interference is existent in order to disprove the claimed bijection. Indeed in the presented calculations for Unruh's setup we have proved that Unruh's which way bijection is *false*. Hence Unruh's analysis is mathematically inconsistent.

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The Algebraic Rainich Conditions

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In the literature, the algebraic Rainich conditions are obtained using special methods such as spinors, duality rotations, an eigenvalue problem for certain 4×4 matrices or artificial tensors of 4th order. We give here an elementary procedure for deducing an identity satisfied by a determined class of second order tensors in arbitrary $\Re^4$, from which the Rainich expressions are immediately obtained.

1 Introduction

Rainich [1–5] proposed a unified field theory for the geometrization of the electromagnetic field, whose basic relations can be obtained from the Einstein-Maxwell field equations:

$$R_{ij} - \frac{1}{2} R\, g_{ij} = -8\pi \left(F_{ib} F^{\cdot b}_{j \cdot} - \frac{1}{4} F_{ab} F^{ab} g_{ij} \right), \qquad (1)$$

where $R_{ac} = R_{ca}$, $R = R^{b\cdot}_{\cdot b}$ and $F_{ac} = -F_{ca}$ are the Ricci tensor, scalar curvature and Faraday tensor [6], respectively.

If in (1) we contract i with j we find that:

$$R = 0 \qquad (2)$$

then (1) adopts the form:

$$R_{ij} = 2\pi F_{ab} F^{ab} g_{ij} - 8\pi F_{ib} F^{\cdot b}_{j \cdot} \qquad (3)$$

used by several authors [1, 2, 5, 7, 8] to obtain the identity:

$$R_{ic} R^{\cdot c}_{j \cdot} = \frac{1}{4} \left(R_{ab} R^{ab} \right) g_{ij} \,. \qquad (4)$$

If F_{ar} is known, then (3) is an equation for g_{ij} and our situation belongs to general relativity. The Rainich theory presents the inverse process: To search for a solution of (2) and (4) (plus certain differential restrictions), and after with (3) to construct the corresponding electromagnetic field; from this point of view F_{ar} is a consequence of the spacetime geometry.

In the next Section we give an elementary proof of (4), without resorting to duality rotations [2], spinors [7], eigenvalue problems [8] or fourth order tensors [9, 10].

2 The algebraic Rainich conditions

The structure of (3) invites us to consider tensors with the form:

$$C_{ij} = A\, g_{ij} + B_{ik} F^{\cdot k}_{j \cdot} \qquad (5)$$

where A is a scalar and B_{ac}, F_{ij} are arbitrary antisymmetric tensors. Then from (5) it is easy to deduce the expression:

$$C_{ia} C^{a\cdot}_{\cdot j} - \frac{C}{2} C_{ij} - \frac{1}{4} \left(C_{ab} C^{ba} - \frac{C^2}{2} \right) g_{ij} = D_{ij} \qquad (6)$$

with $C = C^{r\cdot}_{\cdot r}$ and

$$D_{ij} = B_{ik} F^{ak} B_{am} F^{\cdot m}_{j \cdot} - \frac{1}{2} \left(B^{nm} F_{nm} \right) B_{ib} F^{\cdot b}_{j \cdot} + \\ + \frac{1}{8} \left[\left(B^{nm} F_{nm} \right)^2 - 2 B_{bk} F^{a\cdot}_{\cdot k} B^{\cdot m}_{a \cdot} \right] g_{ij} \,. \qquad (7)$$

But in four dimensions we have the following identities between antisymmetric tensors and their duals [11–13]:

$$B^{m\cdot}_{\cdot c} F^{ic} - {}^{*}B^{ic}\, {}^{*}F^{m\cdot}_{\cdot c} = \frac{1}{2} \left(B_{cd} F^{cd} \right) g^{im}, \\ B^{k\cdot}_{\cdot r}\, {}^{*}B^{ir} = \frac{1}{4} \left(B_{ab}\, {}^{*}B^{ab} \right) g^{ik}. \qquad (8)$$

With (7) and (8) it is simple to prove that $D_{ij} = 0$. Therefore (6) implies the identity:

$$C_{ia} C^{a\cdot}_{\cdot j} - \frac{C}{2} C_{ij} = \frac{1}{4} \left(C_{ab} C^{ba} - \frac{C^2}{2} \right) g_{ij} \,. \qquad (9)$$

If now we consider the particular case:

$$A = 2\pi F_{ab} F^{ab}, \qquad B_{ij} = -8\pi F_{ij} \,, \qquad (10)$$

then (5) reproduces (3) and $C = R = 0$, and thus (9) leads to (4), q.e.d.

Our procedure shows that the algebraic Rainich conditions can be deduced without special techniques.

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The Spacetime Structure of Open Quantum Relativity

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In the framework of the Open Quantum Relativity, we discuss the geodesic and chronological structures related to the embedding procedure and dimensional reduction from 5D to 4D spacetime. The emergence of an extra-force term, the deduction of the masses of particles, two-time arrows and closed time-like solutions are considered leading to a straightforward generalization of causality principle.

1 Introduction

Open Quantum Relativity [1] is a theory based on a dynamical unification scheme [2] of fundamental interactions achieved by assuming a 5D space which allows that the conservation laws are always and absolutely valid as a natural necessity. What we usually describe as violations of conservation laws can be described by a process of embedding and dimensional reduction, which gives rise to an induced-matter theory in the 4D space-time by which the usual masses, spins and charges of particles, naturally spring out. At the same time, it is possible to build up a covariant symplectic structure directly related to general conservation laws [3, 4]. Finally, the theory leads to a dynamical explanation of several paradoxes of modern physics (*e.g.* entanglement of quantum states, quantum teleportation, gamma ray bursts origin, black hole singularities, cosmic primary antimatter absence and a self-consistent fit of all the recently observed cosmological parameters [2, 5, 7, 8, 9]). A fundamental rôle in this approach is the link between the geodesic structure and the field equations of the theory *before* and *after* the dimensional reduction process. The emergence of an Extra Force term in the reduction process and the possibility to recover the masses of particles, allow to reinterpret the Equivalence Principle as a dynamical consequence which naturally "selects" geodesics from metric structure and vice-versa the metric structure from the geodesics. It is worth noting that, following Schrödinger [10], in the Einstein General Relativity, geodesic structure is "imposed" by choosing a Levi-Civita connection [12] and this fact can be criticized considering a completely "affine" approach like in the Palatini formalism [13]. As we will show below, the dimensional reduction process gives rise to the generation of the masses of particles which emerge both from the field equations and the embedded geodesics. Due to this result, the coincidence of chronological and geodesic structure is derived from the embedding and a new dynamical formulation of the Equivalence Principle is the direct consequence of dimensional reduction. The dynamical structure is further rich since two time arrows and closed time-like paths naturally emerge. This fact leads to a reinterpretation of the standard notion of causality which can be, in this way, always recovered, even in the case in which it is questioned (like in entanglement phenomena and quantum teleportation [5, 6]), because it is generalized to a *forward* and a *backward causation*.

The layout of the paper is the following. In Sec.2, we sketch the 5D approach while in Sec.3 we discuss the rôle of conservation laws. Sec.4 is devoted to the discussion of geodesic structure and to the emergence of the Extra Force term. The field equations, the masses of the particles and time-like solutions are discussed in Sec.5. Conclusions are drawn in Sec.6.

2 The 5D-field equations

Open Quantum Relativity can be framed in a 5D space-time manifold and the 4D reduction procedure induces a scalar-tensor theory of gravity where conservation laws (*i.e.* Bianchi identities) play a fundamental rôle into dynamics. The 5D-manifold which we are taking into account is a Riemannian space provided with a 5D-metric of the form

$$dS^2 = g_{AB}\, dx^A dx^B\,, \tag{1}$$

where the Latin indexes are $A, B = 0, 1, 2, 3, 4$. We do not need yet to specify the 5D signature, because, in 4D, it is dynamically fixed by the reduction procedure as we shall see below. The curvature invariants, the field equations and the conservation laws in the 5D-space can be defined as follows. In general, we ask for a space which is a singularity free, smooth manifold, where conservation laws are always valid [7]. The 5D-Riemann tensor is

$$R^D_{ABC} = \partial_B \Gamma^D_{AC} - \partial_C \Gamma^D_{AB} + \Gamma^D_{EB}\Gamma^E_{AC} - \Gamma^D_{EC}\Gamma^E_{AB} \tag{2}$$

and the Ricci tensor and scalar are derived from the contractions

$$R_{AB} = R^C_{ACB}\,, \qquad {}^{(5)}R = R^A_A\,. \tag{3}$$

The field equations can be obtained from the 5D-action

$$ {}^{(5)}\mathcal{A} = -\frac{1}{16\pi\,{}^{(5)}G}\int d^5x\sqrt{-g^{(5)}}\left[{}^{(5)}R\right], \tag{4} $$

where ${}^{(5)}G$ is the 5D-gravitational coupling and $g^{(5)}$ is the determinant of the 5D-metric [2]. The 5D-field equations are

$$ G_{AB} = R_{AB} - \frac{1}{2}\,g_{AB}\,{}^{(5)}R = 0\,, \tag{5} $$

so that at least the Ricci-flat space is always a solution. Let us define now a 5D-stress-energy tensor for a scalar field Φ:

$$ T_{AB} = \nabla_A\Phi\,\nabla_B\Phi - \frac{1}{2}\,g_{AB}\,\nabla_C\Phi\,\nabla^C\Phi\,, \tag{6} $$

where only the kinetic terms are present. As standard, such a tensor can be derived from a variational principle

$$ T^{AB} = \frac{2}{\sqrt{-g^{(5)}}}\frac{\delta\left(\sqrt{-g^{(5)}}\,\mathcal{L}_\Phi\right)}{\delta g_{AB}}\,, \tag{7} $$

where $\mathcal{L}_\Phi$ is a Lagrangian density related to the scalar field Φ. Because of the definition of 5D space itself, based on the conservation laws [7], it is important to stress now that no self-interaction potential $U(\Phi)$ has to be taken into account so that T_{AB} is a completely symmetric object and Φ is, by definition, a cyclic variable. In this situation the Noether theorem always holds for T_{AB}. With these considerations in mind, the field equations can assume the form

$$ R_{AB} = \chi\left(T_{AB} - \frac{1}{2}\,g_{AB}\,T\right), \tag{8} $$

where T is the trace of T_{AB} and $\chi = 8\pi\,{}^{(5)}G$.

3 The rôle of conservation laws

Eqs. (8) are useful to put in evidence the rôle of the scalar field Φ, if we are not simply assuming Ricci-flat 5D-spaces. Due to the symmetry of the stress-energy tensor T_{AB} and the Einstein field equations G_{AB}, the contracted Bianchi identities

$$ \nabla_A\,T^A_B = 0\,, \qquad \nabla_A\,G^A_B = 0\,, \tag{9} $$

must always hold. Developing the stress-energy tensor, we obtain

$$ \nabla_A\,T^A_B = \Phi_B\,{}^{(5)}\Box\Phi\,, \tag{10} $$

where ${}^{(5)}\Box$ is the 5D d'Alembert operator defined as $\nabla_A\Phi^A \equiv \equiv g^{AB}\Phi_{,A;B} \equiv {}^{(5)}\Box\Phi$. The general result is that the conservation of the stress-energy tensor T_{AB} (*i.e.* the contracted Bianchi identities) implies the Klein-Gordon equation which assigns the dynamics of Φ, that is

$$ \nabla_A\,T^A_B = 0 \qquad \Longleftrightarrow \qquad {}^{(5)}\Box\Phi = 0\,. \tag{11} $$

Let us note again the absence of self-interactions due to the absence of potential terms. The relations (11) give a physical meaning to the fifth dimension. Splitting the 5D-problem in a $(4+1)$-description, it is possible to generate the mass of particles in 4D. Such a result can be deduced both from Eq. (11) and from the analysis of the geodesic structure, as we are going to show.

4 The 5D-geodesics and the Extra Force

The geodesic structure of the theory can be derived considering the action

$$ \mathcal{A} = \int dS\left(g_{AB}\frac{dx^A}{dS}\frac{dx^B}{dS}\right)^{1/2}, \tag{12} $$

whose Euler-Lagrange equations are the geodesic equations

$$ \frac{d^2x^A}{dS^2} + \Gamma^A_{BC}\frac{dx^B}{dS}\frac{dx^C}{dS} = 0\,. \tag{13} $$

Γ^A_{BC} are the 5D-Christoffel symbols. Eq. (13) can be split in the $(4+1)$ form

$$ \begin{aligned} 2g_{\alpha\mu}\left(\frac{dx^\alpha}{ds}\right)&\left(\frac{d^2x^\mu}{ds^2} + \Gamma^\mu_{\beta\gamma}\frac{dx^\beta}{ds}\frac{dx^\gamma}{ds}\right) + \\ &+ \frac{\partial g_{\alpha\beta}}{dx^4}\frac{dx^4}{ds}\frac{dx^\alpha}{ds}\frac{dx^\beta}{ds} = 0\,, \end{aligned} \tag{14} $$

where the Greek indexes are $\mu,\nu = 0,1,2,3$ and $ds^2 = = g_{\alpha\beta}dx^\alpha dx^\beta$. Clearly, in the 4D reduction (*i.e.* in the usual spacetime) we ordinarily experience only the standard geodesics of General Relativity, *i.e.* the 4D component of Eq. (14)

$$ \frac{d^2x^\mu}{ds^2} + \Gamma^\mu_{\beta\gamma}\frac{dx^\beta}{ds}\frac{dx^\gamma}{ds} = 0\,, \tag{15} $$

so that, under these conditions, the last part of the representation given by Eq. (14) is not detectable in 4D. In other words, for standard laws of physics, the metric $g_{\alpha\beta}$ does not depend on x^4 in the embedded 4D manifold. On the other hand, the last component of Eq. (14) can be read as an "Extra Force" which gives the motion of a 4D frame with respect to the fifth coordinate x^4. This fact shows that the fifth dimension has a *real physical meaning* and any embedding procedure scaling up in 5D-manifold (or reducing to 4D spacetime) has a dynamical description. The Extra Force

$$ \mathcal{F} = \frac{\partial g_{\alpha\beta}}{dx^4}\frac{dx^4}{ds}\frac{dx^\alpha}{ds}\frac{dx^\beta}{ds}\,, \tag{16} $$

is related to the mass of moving particles in 4D and to the motion of the whole 4D frame. This means that the emergence of this term in Eq. (14), leaving the 5D-geodesic equation verified, gives a new interpretation to the Equivalence Principle in 4D as a dynamical consequence. Looking at Eqs. (14) and (15), we see that in the ordinary 4D spacetime no term, in Eq. (15), is directly related to the masses which are, on the contrary, existing in Eq. (14). In other words, it is the quantity $\mathcal{F}$, which gives the masses to the particles, and this means that the Equivalence Principle can be formulated on a dynamical base by an embedding process. Furthermore the massive particles are different but massless in 5D while, for the physical meaning of the fifth coordinate, they assume mass in 4D thanks to Eq. (16).

Let us now take into account a 5D-null path given by

$$dS^2 = g_{AB}\, dx^A dx^B = 0\,. \tag{17}$$

Splitting Eq. (17) into the 4D part and the fifth component, gives

$$dS^2 = ds^2 + g_{44}\left(dx^4\right)^2 = 0\,. \tag{18}$$

An inspection of Eq. (18) tells that a null path in 5D can result, in 4D, in a time-like path, a space-like path, or a null path depending on the sign and the value of g_{44}. Let us consider now the 5D-vector $u^A = dx^A/dS$. It can be split as a vector in the ordinary 3D-space v, a vector along the ordinary time axis w and a vector along the fifth dimension z. In particular, for 5D null paths, we can have the velocity $v^2 = w^2 + z^2$ and this should lead, in 4D, to super-luminal speed, explicitly overcoming the Lorentz transformations. The problem is solved if we consider the 5D-motion as *a-luminal*, because all particles and fields have the same speed (being massless) and the distinction among super-luminal, luminal and sub-luminal motion (the standard causal motion for massive particles) emerges only *after* the dynamical reduction from 5D-space to 4D spacetime. In this way, the fifth dimension is the entity which, by assigning the masses, is able to generate the different dynamics which we perceive in 4D. Consequently, it is the process of mass generation which sets the particles in the 4D light-cone. Specifically, let us rewrite the expression (16) as

$$\mathcal{F} = \frac{\partial g_{\mu\nu}}{\partial x^4}\frac{dx^4}{ds}\, u^\mu u^\nu. \tag{19}$$

As we said, seen in 4D, this is an Extra Force generated by the motion of the 4D frame with respect to the extra coordinate x^4. This fact shows that all the different particles are massless in 5D and acquire their rest masses m_0 in the dynamical reduction from the 5D to 4D. In fact, considering Eqs. (14) and (18), it is straightforward to derive

$$\mathcal{F} = u^\mu u^\nu\, \frac{\partial g_{\mu\nu}}{\partial x^4}\frac{dx^4}{ds} = \frac{1}{m_0}\frac{dm_0}{ds} = \frac{d\ln(m_0)}{ds}\,, \tag{20}$$

where m_0 has the rôle of a rest mass in 4D, being, from General Relativity,

$$\frac{dx^\mu}{ds} - \frac{1}{2}\frac{\partial g_{\alpha\beta}}{\partial x^\mu}\, u^\alpha u^\beta = 0 \tag{21}$$

and

$$p^\mu = m_0 u^\mu, \qquad p_\mu p^\mu = m_0^2\,, \tag{22}$$

which are, respectively, the definition of linear momentum and the mass-shell condition. Then, it is

$$d\ln(m_0) = \frac{\partial g_{\mu\nu}}{\partial x^4}\, u^\mu u^\nu dx^4 \tag{23}$$

that is

$$m_0 = \exp\int\left(\frac{\partial g_{\mu\nu}}{\partial x^4}\, u^\mu u^\nu dx^4\right) = \exp\int\left(\mathcal{F} dx^4\right). \tag{24}$$

In principle, the term $\int\left(\frac{\partial g_{\mu\nu}}{\partial x^4}\, u^\mu u^\nu dx^4\right)$ never gives a zero mass. However, this term can be less than zero and, with large absolute values, it can asymptotically produce a m_0 very close to zero. In conclusion the Extra Force induced by the reduction from the 5D to the 4D is equal to the derivative of the natural logarithm of the rest mass of a particle with respect to the $(3+1)$ line element and the expression

$$\int\left(\frac{\partial g_{\mu\nu}}{\partial x^4} u^\mu u^\nu dx^4\right) = \int\left(\mathcal{F} dx^4\right) \tag{25}$$

can be read as the total "work" capable of generating masses in the reduction process from 5D to 4D.

5 The field structure and the chronological structure

The results of previous section assume a straightforward physical meaning considering the fifth component of the metric as a scalar field. In this way, the pure "geometric" interpretation of the Extra Force can be framed in a "material" picture. In order to achieve this goal, let us consider the Campbell theorem [15] which states that it is always possible to consider a 4D Riemannian manifold, defined by the line element $ds^2 = g_{\alpha\beta}\, dx^\alpha dx^\beta$, embedded in a 5D one with $dS^2 = g_{AB}\, dx^A dx^B$. We have $g_{AB} = g_{AB}\left(x^\alpha, x^4\right)$ with x^4 the extra coordinate. The metric g_{AB} is covariant under the group of 5D coordinate transformations $x^A \to \overline{x}^A(x^B)$, but not under the restricted group of 4D transformations $x^\alpha \to \overline{x}^\alpha(x^\beta)$. This means, from a physical point of view, that the choice of the 5D coordinate can be read as the *gauge* which specifies the 4D physics. On the other hand, the signature and the value of the fifth coordinate is related to the dynamics generated by the physical quantities which we observe in 4D (mass, spin, charge). Let us start considering the variational principle

$$\delta\int d^{(5)}x\sqrt{-g^{(5)}}\left[{}^{(5)}R + \lambda(g_{44} - \epsilon\Phi^2)\right] = 0\,, \tag{26}$$

derived from (4) where λ is a Lagrange multiplier, Φ a generic scalar field and $\epsilon = \pm 1$. This procedure allows to derive the physical gauge for the 5D metric. The above 5D metric can be immediately rewritten as

$$\begin{aligned} dS^2 = g_{AB}\, dx^A dx^B = g_{\alpha\beta} dx^\alpha dx^\beta + g_{44}\left(dx^4\right)^2 = \\ = g_{\alpha\beta}\, dx^\alpha dx^\beta + \epsilon\, \Phi^2\left(dx^4\right)^2, \end{aligned} \tag{27}$$

where the signature $\epsilon = -1$ can be interpreted as "particle like" solutions while $\epsilon = +1$ gives rise to wave-like solutions. The physical meaning of these distinct classes of solutions, as we will see below, is crucial. Assuming a standard signature $(+\ -\ --)$ for the 4D component of the metric, the 5D metric can be written as the matrix

$$g_{AB} = \begin{pmatrix} g_{\alpha\beta} & 0 \\ 0 & \epsilon\,\Phi^2 \end{pmatrix}, \tag{28}$$

and the 5D Ricci curvature tensor is

$$\begin{aligned} {}^{(5)}R_{\alpha\beta} = R_{\alpha\beta} - \frac{\Phi_{,\alpha;\beta}}{\Phi} + \frac{\epsilon}{2\,\Phi^2}\Bigg(\frac{\Phi_{,4}\,g_{\alpha\beta,4}}{\Phi} - \\ - g_{\alpha\beta,44} + g^{\lambda\mu}g_{\alpha\lambda,4}\,g_{\beta\mu,4} - \frac{g^{\mu\nu}g_{\mu\nu,4}\,g_{\alpha\beta,4}}{2}\Bigg) \end{aligned} \tag{29}$$

where $R_{\alpha\beta}$ is the 4D Ricci tensor. After the projection from 5D to 4D, $g_{\alpha\beta}$, derived from g_{AB}, no longer explicitly depends on x^4, and then the 5D Ricci scalar assumes the remarkable expression:

$${}^{(5)}R = R - \frac{1}{\Phi}\,\Box\Phi\,, \tag{30}$$

where the $\Box$ is now the 4D d'Alembert operator. The action in Eq. (26) can be recast in a 4D Brans-Dicke form

$$\mathcal{A} = -\frac{1}{16\pi G_N}\int d^4x\sqrt{-g}\,[\Phi R + \mathcal{L}_\Phi]\,, \tag{31}$$

where the Newton constant is given by

$$G_N = \frac{{}^{(5)}G}{2\pi l} \tag{32}$$

where l is a characteristic length in 5D. Defining a generic function of a 4D scalar field φ as

$$-\frac{\Phi}{16\pi G_N} = F(\varphi) \tag{33}$$

we get a 4D general action in which gravity is nonminimally coupled to a scalar field [2, 16, 17]:

$$\begin{aligned} \mathcal{A} = \int_{\mathcal{M}} d^4x\,\times \\ \times\sqrt{-g}\left[F(\varphi)R + \frac{1}{2}\,g^{\mu\nu}\varphi_{;\mu}\,\varphi_{;\nu} - V(\varphi) + \mathcal{L}_m\right] \end{aligned} \tag{34}$$

$F(\varphi)$ and $V(\varphi)$ are a generic coupling and a self interacting potential respectively. The field equations can be derived by varying with respect to the 4D metric $g_{\mu\nu}$

$$R_{\mu\nu} - \frac{1}{2}\,g_{\mu\nu}R = \tilde{T}_{\mu\nu}\,, \tag{35}$$

where

$$\begin{aligned} \tilde{T}_{\mu\nu} = \frac{1}{F(\varphi)}\Bigg\{-\frac{1}{2}\,\varphi_{;\mu}\varphi_{;\nu} + \frac{1}{4}\,g_{\mu\nu}\varphi_{;\alpha}\varphi^{;\alpha} - \\ - \frac{1}{2}\,g_{\mu\nu}V(\varphi) - g_{\mu\nu}\Box F(\varphi) + F(\varphi)_{;\mu\nu}\Bigg\} \end{aligned} \tag{36}$$

is the effective stress–energy tensor containing the nonminimal coupling contributions, the kinetic terms and the potential of the scalar field φ. By varying with respect to φ, we get the 4D Klein-Gordon equation

$$\Box\varphi - RF'(\varphi) + V'(\varphi) = 0\,, \tag{37}$$

where primes indicate derivatives with respect to φ.

Eq. (37) is the contracted Bianchi identity demonstrating the recovering of conservation laws also in 4D [2]. This feature means that the effective stress-energy tensor at right hand side of (35) is a zero-divergence tensor and this fact is fully compatible with Einstein theory of gravity also starting from a 5D space. Specifically, the reduction procedure from 5D to 4D preserves all the features of standard General Relativity. In order to achieve the physical identification of the fifth dimension, let us recast the generalized Klein-Gordon equation (37) as

$$\left(\Box + m^2_{\text{eff}}\right)\varphi = 0\,, \tag{38}$$

where

$$m^2_{\text{eff}} = \left[V'(\varphi) - RF'(\varphi)\right]\varphi^{-1} \tag{39}$$

is the effective mass, *i.e.* a function of φ, where self-gravity contributions $RF'(\varphi)$ and scalar field self interactions $V'(\varphi)$ are taken into account [18]. This means that a natural way to generate the masses of particles can be achieved starting from a 5D picture and the concept of *mass* can be recovered as a geometric derivation according to the Extra Force of previous section. In other words, the chronological structure and the geodesic structure of the reduction process from 5D to 4D naturally coincide since the the masses generated in both cases are equivalent. From an epistemological point of view, this new result clearly demonstrates why geodesic structure and chronological structure can be assumed to coincide in General Relativity using the Levi-Civita connection in both the Palatini and the metric approaches [13]. Explicitly the 5D d'Alembert operator can be split, considering the 5D metric in the form (27) for particle-like solutions:

$${}^{(5)}\Box = \Box - {\partial_4}^2\,. \tag{40}$$

This means that we are considering $\epsilon = -1$. We have then

$${}^{(5)}\Box\Phi = \left[\Box - {\partial_4}^2\right]\Phi = 0\,. \tag{41}$$

Separating the variables and splitting the scalar field Φ into two functions

$$\Phi = \varphi(t,\vec{x})\,\chi(x^4)\,, \tag{42}$$

the field φ depends on the ordinary space-time coordinates, while χ is a function of the fifth coordinate x^4. Inserting (42) into Eq. (41), we get

$$\frac{\Box\varphi}{\varphi} = \frac{1}{\chi}\left[\frac{d^2\chi}{dx_4^2}\right] = -k_n^2 \tag{43}$$

where k_n is a constant. From Eq. (43), we obtain the two field equations

$$\left(\Box + k_n^2\right)\varphi = 0\,, \tag{44}$$

and

$$\frac{d^2\chi}{dx_4^2} + k_n^2\,\chi = 0\,. \tag{45}$$

Eq. (45) describes a harmonic oscillator whose general solution is

$$\chi(x_4) = c_1 e^{-ik_n x^4} + c_2 e^{ik_n x^4}\,. \tag{46}$$

The constant k_n has the physical dimension of the inverse of a length and, assigning boundary conditions, we can derive the eigenvalue relation

$$k_n = \frac{2\pi}{l}\,n\,, \tag{47}$$

where n is an integer and l a length which we have previously defined in Eq. (32) related to the gravitational coupling. As a result, in standard units, we can recover the physical lengths through the Compton lengths

$$\lambda_n = \frac{\hbar}{2\pi m_n c} = \frac{1}{k_n} \tag{48}$$

which always assign the masses to the particles depending on the number n. It is worth stressing that, in this case, we have achieved a dynamical approach because the eigenvalues of Eq. (45) are the masses of particles which are generated by the process of reduction from 5D to 4D. The solution (46) is the superposition of two mass eigenstates. The 4D evolution is given by Eq. (38) or, equivalently, (44). Besides, the solutions in the coordinate x^4 give the associated Compton lengths from which the effective physical masses can be derived. Specifically, different values of n fix the families of particles, while, for any given value n, different values of parameters $c_{1,2}$ select the different particles within a family. With these considerations in mind, the effective mass can be obtained integrating the modulus of the scalar field Φ along the x^4 coordinate. It is

$$m_{\text{eff}} \equiv \int |\Phi| dx^4 = \int |\Phi\,(dx^4/ds)|\,ds \tag{49}$$

where ds is the 4D affine parameter used in the derivation of geodesic equation. This result means that the rest mass of a particle is derived by integrating the Extra Force along x^4 (see Eq. 24) while the effective mass is obtained by integrating the field Φ along x^4. In the first case, the mass of the particle is obtained starting from the geodesic structure of the theory, in the second case, it comes out from the field structure. In other words, the coincidence of geodesic structure and chronological structure (the causal structure), supposed as a principle in General Relativity, is due to the fact that masses are generated in the reduction process.

At this point, from the condition (42), the field 5D Φ results to be

$$\Phi(x^\alpha, x^4) = \sum_{n=-\infty}^{+\infty}\left[\varphi_n(x^\alpha)e^{-ik_n x^4} + \varphi_n^*(x^\alpha)e^{ik_n x^4}\right], \tag{50}$$

where φ and φ^* are the 4D solutions combined with the fifth-component solutions $e^{\pm ik_n x^4}$. In general, every particle mass can be selected by solutions of type (46). The number $k_n x^4$, *i.e.* the ratio between the two lengths x^4/λ_n, fixes the interaction scale. Geometrically, such a scale is related to the curvature radius of the embedded 4D spacetime where particles can be identified and, in principle, detected. In this sense, Open Quantum Relativity is an *induced-matter* theory, where the extra dimension cannot be simply classified as "compactified" since it yields all the 4D dynamics giving origin to the masses. Moreover, Eq. (50) is not a simple "tower of mass states" but a spectrum capable of explaining the hierarchy problem [7]. On the other hand, gravitational interaction can be framed in this approach considering as its fundamental scale the Planck length

$$\lambda_P = l = \left(\frac{\hbar G_N}{c^3}\right)^{1/2}, \tag{51}$$

instead of the above Compton length. It fixes the vacuum state of the system ant the masses of all particles can be considered negligible if compared with the Planck scales. Finally, as we have seen, the reduction mechanism can select also $\epsilon = 1$ in the metric (27). In this case, the 5D-Klein Gordon equation (11), and the 5D field equations (5) have wave-like solutions of the form

$$dS^2 = dt^2 - \Omega\,(t, x_1)\left(dx^1\right)^2 - \Omega\,(t, x_2)\left(dx^2\right)^2 - \\ - \Omega\,(t, x_3)\left(dx^3\right)^2 + \left(dx^4\right)^2, \tag{52}$$

where

$$\Omega\,(t, x_j) = \exp i(\omega t + k_j x^j)\,, \quad j = 1, 2, 3\,. \tag{53}$$

In this solution, the necessity of the existence of two times arrows naturally emerges and, as a direct consequence, due to the structure of the functions $\Omega\,(t, x_j)$, closed time-like paths (*i.e.* circular paths) are allowed. The existence of closed time-like paths means that Anti-De Sitter [14] and Gödel [11] solutions are naturally allowed possibilities in the dynamics.

6 Discussion and conclusions

In this paper, we have discussed the reduction process which allows to recover the 4D spacetime and dynamics starting from the 5D manifold of Open Quantum Relativity. Such a theory needs, to be formulated, a *General Conservation Principle*. This principle states that conservation laws are always and absolutely valid also when, to maintain such a validity, phenomena as topology changes and entanglement can emerge in 4D. In this way, we have a theory without singularities (like conventional black holes) and unphysical spacetime regions are naturally avoided [8, 6]. The dimensional reduction can be considered from the geodesic structure and the field equations points of view. In the first case, starting from a 5D metric, it is possible to generate an Extra Force term in 4D which is related to the rest masses of particles and then to the Equivalence Principle. In fact, masses can be dynamically generated by the fifth component of the 5D space and the relation between inertial mass and gravitational mass is not an assumed principle, as in standard physics [10], but the result of the dynamical process of embedding. It is worth noting that an "amount of work" is necessary to give the mass to a particle. An effective mass is recovered also by splitting the field equations in a $(4+1)$ formalism. The fifth component of the metric can be interpreted as a scalar field and the embedding as the process by which the mass of particles emerges. The fact that particles acquire the mass from the embedding of geodesics and from the embedding of field equations is the reason why the chronological and geodesic structures of the 4D spacetime are the same: they can be both achieved from the same 5D metric structure which is also the solution of the 5D field equations. By taking into account such a result in 4D, the result itself naturally leads to understand why the metric approach of General Relativity, based on Levi-Civita connections, succeed in the description of spacetime dynamics even without resorting to a more general scheme as the Palatini-affine approach where connection and metric are, in principle, considered distinct. The reduction process leads also to a wide class of time solutions including two-time arrows and closed time-like paths. As a consequence, we can recover the concept of causality questioned by the EPR effect [6] thanks to the necessary introduction of backward and forward causation [1]. As a final remark, we can say that Open Quantum Relativity is an approach which allows to face Quantum Mechanics and Relativity under the same dynamical standard (a covariant symplectic structure [3]): this occurrence leads to frame several paradoxes of modern physics under the same dynamical scheme by only an assumption of the absolute validity of conservation laws and the generalization of the causal structure of spacetime.

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Yang-Mills Field from Quaternion Space Geometry, and Its Klein-Gordon Representation

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Analysis of covariant derivatives of vectors in quaternion (Q-) spaces performed using Q-unit spinor-splitting technique and use of SL(2C)-invariance of quaternion multiplication reveals close connexion of Q-geometry objects and Yang-Mills (YM) field principle characteristics. In particular, it is shown that Q-connexion (with quaternion non-metricity) and related curvature of 4 dimensional (4D) space-times with 3D Q-space sections are formally equivalent to respectively YM-field potential and strength, traditionally emerging from the minimal action assumption. Plausible links between YM field equation and Klein-Gordon equation, in particular via its known isomorphism with Duffin-Kemmer equation, are also discussed.

1 Introduction

Traditionally YM field is treated as a gauge, "*auxiliary*", field involved to compensate local transformations of a 'main' (e.g. spinor) field to keep invariance of respective action functional. Anyway there are a number of works where YM-field features are found related to some geometric properties of space-times of different types, mainly in connexion with contemporary gravity theories.

Thus in paper [1] violation of $SO(3,1)$-covariance in gauge gravitation theory caused by distinguishing time direction from normal space-like hyper-surfaces is regarded as spontaneous symmetry violation analogous to introduction of mass in YM theory. Paper [2] shows a generic approach to formulation of a physical field evolution based on description of differential manifold and its mapping onto "model" spaces defined by characteristic groups; the group choice leads to gravity or YM theory equations. Furthermore it can be shown [2b] that it is possible to describe altogether gravitation in a space with torsion, and electroweak interactions on 4D real spacetime C^2, so we have in usual spacetime with torsion a unified theory (modulo the non treatment of the strong forces).

Somewhat different approach is suggested in paper [3] where gauge potentials and tensions are related respectively to connexion and curvature of principle bundle, whose base and gauge group choice allows arriving either to YM or to gravitation theory. Paper [4] dealing with gravity in Riemann-Cartan space and Lagrangian quadratic in connexion and curvature shows possibility to interpret connexion as a mediator of YM interaction.

In paper [5] a unified theory of gravity and electroweak forces is built with Lagrangian as a scalar curvature of space-time with torsion; if trace and axial part of the torsion vanish the Lagrangian is shown to separate into Gilbert and YM parts. Regardless of somehow artificial character of used models, these observations nonetheless hint that there may exist a deep link between supposedly really physical object, YM field and pure math constructions. A surprising analogy between main characteristics of YM field and mathematical objects is found hidden within geometry induced by quaternion (Q-) numbers.

In this regard, the role played by Yang-Mills field cannot be overemphasized, in particular from the viewpoint of the Standard Model of elementary particles. While there are a number of attempts for describing the Standard Model of hadrons and leptons from the viewpoint of classical electromagnetic Maxwell equations [6, 7], nonetheless this question remains an open problem. An alternative route toward achieving this goal is by using quaternion number, as described in the present paper. In fact, in Ref. [7] a somewhat similar approach with ours has been described, i.e. the generalized Cauchy-Riemann equations contain 2-spinor and C-gauge structures, and their integrability conditions take the form of Maxwell and Yang-Mills equations.

It is long ago noticed that Q-math (algebra, calculus and related geometry) naturally comprise many features attributed to physical systems and laws. It is known that quaternions describe three "imaginary" Q-units as unit vectors directing axes of a Cartesian system of coordinates (it was initially developed to represent subsequent telescope motions in astronomical observation). Maxwell used the fact to write his equations in the most convenient Q-form. Decades later Fueter discovered a formidable coincidence: a pure math Cauchy-Riemann type condition endowing functions of Q-variable with analytical properties turned out to be identical in shape to vacuum equations of electrodynamics [9].

Later on other surprising Q-math — physics coincidences were found. Among them: "automatic" appearance of Pauli magnetic field-spin term with Bohr magneton as a coefficient when Hamiltonian for charged quantum mechanical particle was built with the help of Q-based metric [10]; possibility to endow "imaginary" vector Q-units with properties of not only stationary but movable triad of Cartan type and use it for a very simple description of Newtonian mechanics in rotating frame of reference [11]; discovery of inherited in Q-math variant of relativity theory permitting to describe motion of non-inertial frames [12]. Preliminary study shows that YM field components are also formally present in Q-math.

In Section 2 notion of Q-space is given in necessary detail. Section 3 discussed neat analogy between Q-geometric objects and YM field potential and strength. In Section 4 YM field and Klein-Gordon correspondence is discussed. Concluding remarks can be found in Section 5.

Part of our motivation for writing this paper was to explicate the hidden electromagnetic field origin of YM fields. It is known that the Standard Model of elementary particles lack systematic description for the mechanism of quark charges. (Let alone the question of whether quarks do exist or they are mere algebraic tools, as Heisenberg once puts forth: *If quarks exist, then we have redefined the word "exist".*) On the other side, as described above, Maxwell described his theory in quaternionic language, therefore it seems natural to ask whether it is possible to find neat link between quaternion language and YM-fields, and by doing so provide one step toward describing mechanism behind quark charges.

Further experimental observation is of course recommended in order to verify or refute our propositions as described herein.

2 Quaternion spaces

Detailed description of Q-space is given in [13]; shortly but with necessary strictness its notion can be presented as following.

Let U_N be a manifold, a geometric object consisting of points $M \in U_N$ each reciprocally and uniquely corresponding to a set of N numbers-coordinates $\{y^A\} : M \leftrightarrow \{y^A\}$, $(A = 1, 2 \dots N)$. Also let the sets of coordinates be transformed so that the map becomes a homeomorphism of a class C_k. It is known that U_N may be endowed with a proper tangent manifold T_N described by sets of orthogonal unite vectors $\mathbf{e}_{(A)}$ generating in T_N families of coordinate lines $M \to \{X^{(A)}\}$, indices in brackets being numbers of frames' vectors. Differentials of coordinates in U_N and T_N are tied as $dX^{(A)} = g^{(A)}_B dy^B$, with Lamé coefficients $g^{(A)}_B$, functions of y^A, so that $X^{(A)}$ are generally non-holonomic. Irrespectively of properties of U_N each its point may be attached to the origin of a frame, in particular presented by "imaginary" Q-units $\mathbf{q}_k$, this attachment accompanied by a rule tying values of coordinates of this point with the triad orientation $M \leftrightarrow \{y^A, \Phi_\xi\}$. All triads $\{\mathbf{q}_k\}$ so defined on U_N form a sort of "tangent" manifold $T(U, \mathbf{q})$, (really tangent only for the base U_3). Due to presence of frame vectors $\mathbf{q}_k(y)$ existence of metric and at least proper (quaternionic) connexion $\omega_{jkn} = -\omega_{jnk}$, $\partial_j \mathbf{q}_k = \omega_{jkn} \mathbf{q}_n$, is implied, hence one can tell of $T(U, \mathbf{q})$ as of a Q-tangent space on the base U_N. Coordinates x_k defined along triad vectors $\mathbf{q}_k$ in $T(U, \mathbf{q})$ are tied with non-holonomic coordinates $X^{(A)}$ in proper tangent space T_N by the transformation $dx_k \equiv h_{k(A)} dX^{(A)}$ with $h_{k(A)}$ being locally depending matrices (and generally not square) of relative $\mathbf{e}_{(A)} \leftrightarrow \mathbf{q}_k$ rotation. Consider a special case of unification $U \oplus T(U, \mathbf{q})$ with 3-dimensional base space $U = \mathbf{U}_3$. Moreover, let quaternion specificity of T_3 reflects property of the base itself, i.e. metric structure of $\mathbf{U}_3$ inevitably requires involvement of Q-triads to initiate Cartesian coordinates in its tangent space. Such 3-dimensional space generating sets of tangent quaternionic frames in each its point is named here "quaternion space" (or simply Q-space). Main distinguishing feature of a Q-space is non-symmetric form of its metric tensor* $\mathbf{g}_{kn} \equiv \mathbf{q}_k \mathbf{q}_n = -\delta_{kn} + \varepsilon_{knj} \mathbf{q}_j$ being in fact multiplication rule of "imaginary" Q-units. It is easy to understand that all tangent spaces constructed on arbitrary bases as designed above are Q-spaces themselves. In most general case a Q-space can be treated as a space of affine connexion $\Omega_{jkn} = \Gamma_{jkn} + Q_{jkn} + S_{jkn} + \omega_{jnk} + \sigma_{jkn}$ comprising respectively Riemann connexion Γ_{jkn}, Cartan contorsion Q_{jkn}, segmentary curvature (or ordinary non-metricity) S_{jkn}, Q-connexion ω_{jnk}, and Q-non-metricity σ_{jkn}; curvature tensor is given by standard expression $R_{knij} = \partial_i \Omega_{j\,kn} - \partial_j \Omega_{i\,kn} + \Omega_{i\,km} \Omega_{j\,mn} - \Omega_{j\,nm} \Omega_{i\,mk}$. Presence or vanishing of different parts of connexion or curvature results in multiple variants of Q-spaces classification [13]. Further on only Q-spaces with pure quaternionic characteristics (Q-connexion and Q-non-metricity) will be considered.

3 Yang-Mills field from Q-space geometry

Usually Yang-Mills field $A_{B\mu}$ is introduced as a gauge field in procedure of localized transformations of certain field, e.g. spinor field [14, 15]

$$\psi_a \to U(y^\beta)\, \psi_a \,. \tag{1}$$

If in the Lagrangian of the field partial derivative of ψ_a is changed to "covariant" one

$$\partial_\beta \to D_\beta \equiv \partial_\beta - g A_\beta \,, \tag{2}$$

*Latin indices are 3D, Greek indices are 4D; δ_{kn}, ε_{knj} are Kronecker and Levi-Civita symbols; summation convention is valid.

$$A_\beta \equiv i A_{C\,\beta} \mathbf{T}_C \,, \tag{3}$$

where g is a real constant (parameter of the model), $\mathbf{T}_C$ are traceless matrices (Lie-group generators) commuting as

$$[\mathbf{T}_B,\, \mathbf{T}_C] = i f_{BCD} \mathbf{T}_D \tag{4}$$

with structure constants f_{BCD}, then

$$D_\beta U \equiv (\partial_\beta - g A_\beta)\, U = 0\,, \tag{5}$$

and the Lagrangian keeps invariant under the transformations (1). The theory becomes "self consistent" if the gauge field terms are added to Lagrangian

$$L_{YM} \sim F^{\alpha\beta} F_{\alpha\beta}\,, \tag{6}$$

$$F_{\alpha\beta} \equiv F_{C\,\alpha\beta}\, \mathbf{T}_C\,. \tag{7}$$

The gauge field intensity $F_B^{\mu\nu}$ expressed through potentials $A_{B\mu}$ and structure constants as

$$F_{C\,\alpha\beta} = \partial_\alpha A_{C\,\beta} - \partial_\beta A_{C\,\alpha} + f_{CDE}\, A_{D\,\alpha} A_{E\,\beta}\,. \tag{8}$$

Vacuum equations of the gauge field

$$\partial_\alpha F^{\alpha\beta} + \left[A_\alpha, F^{\alpha\beta}\right] = 0 \tag{9}$$

are result of variation procedure of action built from Lagrangian (6).

Group Lie, e.g. SU(2) generators in particular can be represented by "imaginary" quaternion units given by e.g. traceless 2×2-matrices in special representation (Pauli-type) $i\mathbf{T}_B \rightarrow \mathbf{q}_{\tilde{k}} = -i\sigma_k$ (σ_k are Pauli matrices),

Then the structure constants are Levi-Civita tensor components $f_{BCD} \rightarrow \varepsilon_{knm}$, and expressions for potential and intensity (strength) of the gauge field are written as:

$$A_\beta = g\, \frac{1}{2}\, A_{\tilde{k}\,\beta} \mathbf{q}_{\tilde{k}}\,, \tag{10}$$

$$F_{k\,\alpha\beta} = \partial_\alpha A_{k\,\beta} - \partial_\beta A_{k\,\alpha} + \varepsilon_{kmn}\, A_{m\,\alpha} A_{n\,\beta}\,. \tag{11}$$

It is worthnoting that this conventional method of introduction of a Yang-Mills field type essentially exploits *heuristic base* of theoretical physics, first of all the postulate of minimal action and formalism of Lagrangian functions construction. But since description of the field optionally uses quaternion units one can assume that some of the above relations are appropriate for Q-spaces theory and may have geometric analogues. To verify this assumption we will use an example of 4D space-time model with 3D spatial quaternion section.

Begin with the problem of 4D space-time with 3D spatial section in the form of Q-space containing only one geometric object: proper quaternion connexion. Q-covariant derivative of the basic (frame) vectors $\mathbf{q}_m$ identically vanish in this space:

$$\tilde{D}_\alpha \mathbf{q}_k \equiv (\delta_{mk}\, \partial_\alpha + \omega_{\alpha\, mk})\, \mathbf{q}_m = 0\,. \tag{12}$$

This equation is in fact equivalent to definition of the proper connexion $\omega_{\alpha\, mk}$. If a transformation of Q-units is given by spinor group (leaving quaternion multiplication rule invariant)

$$\mathbf{q}_k = U(y)\, \mathbf{q}_{\tilde{k}}\, U^{-1}(y) \tag{13}$$

($\mathbf{q}_{\tilde{k}}$ are constants here) then Eq. (12) yields

$$\partial_\alpha U\, \mathbf{q}_{\tilde{k}}\, U^{-1} + U\, \mathbf{q}_{\tilde{k}}\, \partial_\alpha U^{-1} = \omega_{\alpha k n}\, U\, \mathbf{q}_{\tilde{n}}\, U^{-1}. \tag{14}$$

But one can easily verify that each "imaginary" Q-unit $\mathbf{q}_{\tilde{k}}$ can be always represented in the form of tensor product of its eigen-functions (EF) $\psi_{(\tilde{k})}$, $\varphi_{(\tilde{k})}$ (no summation convention for indices in brackets):

$$\mathbf{q}_{\tilde{k}}\, \psi_{(\tilde{k})} = \pm i \psi_{(\tilde{k})}, \qquad \varphi_{(\tilde{k})} \mathbf{q}_{\tilde{k}} = \pm i \varphi_{(\tilde{k})} \tag{15}$$

having spinor structure (here only EF with positive parity (with sign +) are shown)

$$\mathbf{q}_{\tilde{k}} = i\,(2\psi_{(\tilde{k})}\varphi_{(\tilde{k})} - 1); \tag{16}$$

this means that left-hand-side (lhs) of Eq. (14) can be equivalently rewritten in the form

$$\begin{aligned} &\frac{1}{2}\,(\partial_\alpha U\, \mathbf{q}_{\tilde{k}}\, U^{-1} + U\, \mathbf{q}_{\tilde{k}}\, \partial_\alpha U^{-1}) = \\ &\quad = (\partial_\alpha U\, \psi_{(\tilde{k})})\, \varphi_{(\tilde{k})} U^{-1} + U\, \psi_{(\tilde{k})}\, (\varphi_{(\tilde{k})} \partial_\alpha U^{-1}) \end{aligned} \tag{17}$$

which strongly resembles use of Eq. (1) for transformations of spinor functions.

Here we for the first time underline a remarkable fact: *form-invariance of multiplication rule of Q-units under their spinor transformations gives expressions similar to those conventionally used to initiate introduction of gauge fields of Yang-Mills type.*

Now in order to determine mathematical analogues of these "physical fields", we will analyze in more details Eq. (14). Its multiplication (from the right) by combination $U\, \mathbf{q}_{\tilde{k}}$ with contraction by index $\tilde{k}$ leads to the expression

$$-3\, \partial_\alpha U \;+ U\, \mathbf{q}_{\tilde{k}}\, \partial_\alpha U^{-1} U \mathbf{q}_{\tilde{k}} = \omega_{\alpha k n}\, U\, \mathbf{q}_{\tilde{n}}\, \mathbf{q}_{\tilde{k}}\,. \tag{18}$$

This matrix equation can be simplified with the help of the always possible development of transformation matrices

$$U \equiv a \;+ b_k\, \mathbf{q}_{\tilde{k}}\,, \qquad U^{-1} = a \;- b_k\, \mathbf{q}_{\tilde{k}}\,, \tag{19}$$

$$U U^{-1} = a^2 \;+ b_k\, b_k = 1\,, \tag{20}$$

where a, b_k are real scalar and 3D-vector functions, $\mathbf{q}_{\tilde{k}}$ are Q-units in special (Pauli-type) representation. Using Eqs. (19), the second term in lhs of Eq. (18) after some algebra is reduced to remarkably simple expression

$$\begin{aligned} &U\, \mathbf{q}_{\tilde{k}}\, \partial_\alpha U^{-1} U \mathbf{q}_{\tilde{k}} = \\ &= \,(a + b_n \mathbf{q}_{\tilde{n}})\, \mathbf{q}_{\tilde{k}} (\partial_\alpha a - \partial_\alpha b_m \mathbf{q}_{\tilde{m}})\, (a + b_l\, \mathbf{q}_{\tilde{l}})\, \mathbf{q}_{\tilde{k}} = \\ &= \,\partial_\alpha (a + b_n \mathbf{q}_{\tilde{n}}) = -\,\partial_\alpha U \end{aligned} \tag{21}$$

so that altogether lhs of Eq. (18) comprises $-4\,\partial_\alpha U$ while right-hand-side (rhs) is

$$\omega_{\alpha kn}\, U\, \mathbf{q}_{\tilde{n}} \mathbf{q}_{\tilde{k}} = -\varepsilon_{knm}\omega_{\alpha kn}\, U\, \mathbf{q}_{\tilde{m}}\,; \tag{22}$$

then Eq. (18) yields

$$\partial_\alpha U - \frac{1}{4}\,\varepsilon_{knm}\omega_{\alpha kn}\, U\, \mathbf{q}_{\tilde{m}} = 0\,. \tag{23}$$

If now one makes the following notations

$$A_{k\,\alpha} \equiv \frac{1}{2}\,\varepsilon_{knm}\,\omega_{\alpha kn}\,, \tag{24}$$

$$A_{\alpha} \equiv \frac{1}{2}\,A_n \mathbf{q}_{\tilde{n}}\,, \tag{25}$$

then notation (25) exactly coincides with the definition (10) (provided $g = 1$), and Eq. (23) turns out equivalent to Eq. (5)

$$U \overleftarrow{D}_\alpha \equiv U(\overleftarrow{\partial}_\alpha - A_\alpha) = 0\,. \tag{26}$$

Expression for "covariant derivative" of inverse matrix follows from the identity:

$$\partial_\alpha U\, U^{-1} = -U\partial_\alpha U^{-1}. \tag{27}$$

Using Eq. (23) one easily computes

$$-\partial_\alpha U^{-1} - \frac{1}{4}\,\varepsilon_{knm}\,\omega_{\alpha kn}\,\mathbf{q}_{\tilde{m}} U^{-1} = 0 \tag{28}$$

or

$$D_\alpha U^{-1} \equiv (\partial_\alpha + A_\alpha)\, U^{-1} = 0\,. \tag{29}$$

Direction of action of the derivative operator is not essential here, since the substitution $U^{-1} \to U$ и $U \to U^{-1}$ is always possible, and then Eq. (29) exactly coincides with Eq. (5).

Now let us summarize first results. We have a remarkable fact: form-invariance of Q-multiplication has as a corollary "covariant constancy" of matrices of spinor transformations of vector Q-units; moreover one notes that proper Q-connexion (contracted in skew indices by Levi-Civita tensor) plays the role of "gauge potential" of some Yang-Mills-type field. By the way the Q-connexion is easily expressed from Eq. (24)

$$\omega_{\alpha kn} = \varepsilon_{mkn} A_{m\,\alpha}\,. \tag{30}$$

Using Eq. (25) one finds expression for the gauge field intensity (11) (contracted by Levi-Civita tensor for convenience) through Q-connexion

$$\begin{aligned} &\varepsilon_{kmn} F_{k\,\alpha\beta} = \\ &= \varepsilon_{kmn}(\partial_\alpha A_{k\,\beta} - \partial_\beta A_{k\,\alpha}) + \varepsilon_{kmn}\varepsilon_{mlj} A_{l\,\alpha} A_{j\,\beta} = \\ &= \partial_\alpha \omega_{\beta\,mn} - \partial_\beta \omega_{\alpha\,mn} + A_{m\,\alpha} A_{n\,\beta} - A_{m\beta} A_{n\alpha}\,. \end{aligned} \tag{31}$$

If identically vanishing sum

$$-\delta_{mn} A_{j\,\alpha} A_{j\,\beta} + \delta_{mn} A_{j\beta} A_{j\alpha} = 0 \tag{32}$$

is added to rhs of (31) then all quadratic terms in the right hand side can be given in the form

$$\begin{aligned} &A_{m\,\alpha} A_{n\,\beta} - A_{m\beta} A_{n\,\alpha} - \delta_{mn} A_{j\,\alpha} A_{j\,\beta} + \delta_{mn} A_{j\beta} A_{j\alpha} = \\ &= (\delta_{mp}\delta_{qn} - \delta_{mn}\delta_{qp})(A_{p\,\alpha} A_{q\,\beta} - A_{p\beta} A_{q\,\alpha}) = \\ &= \varepsilon_{kmq}\varepsilon_{kpn}(A_{p\,\alpha} A_{q\,\beta} - A_{p\beta} A_{q\,\alpha}) = \\ &= -\,\omega_{\alpha\,kn}\,\omega_{\beta\,km} + \omega_{\beta\,kn} A_{\alpha\,km}\,. \end{aligned}$$

Substitution of the last expression into Eq. (31) accompanied with new notation

$$R_{mn\,\alpha\beta} \equiv \varepsilon_{kmn} F_{k\,\alpha\beta} \tag{33}$$

leads to well-known formula:

$$\begin{aligned} R_{mn\,\alpha\beta} = \partial_\alpha \omega_{\beta\,mn} - \partial_\beta \omega_{\alpha\,mn} + \\ + \omega_{\alpha\,nk}\,\omega_{\beta\,km} - \omega_{\beta\,nk}\,\omega_{\alpha\,km}\,. \end{aligned} \tag{34}$$

This is nothing else but curvature tensor of Q-space built out of proper Q-connexion components (in their turn being functions of 4D coordinates). By other words, Yang-Mills field strength is mathematically (geometrically) identical to quaternion space curvature tensor. But in the considered case of Q-space comprising only proper Q-connexion, all components of the curvature tensor are identically zero. So Yang-Mills field in this case has potential but no intensity.

The picture absolutely changes for the case of quaternion space with Q-connexion containing a proper part $\omega_{\beta\,kn}$ and also Q-non-metricity $\sigma_{\beta\,kn}$

$$\Omega_{\beta\,kn}(y^\alpha) = \omega_{\beta\,kn} + \sigma_{\beta\,kn} \tag{35}$$

so that Q-covariant derivative of a unite Q-vector with connexion (35) does not vanish, its result is namely the Q-non-metricity

$$\hat{D}_\alpha \mathbf{q}_k \equiv (\delta_{mk}\partial_\alpha + \Omega_{\alpha\,mk})\,\mathbf{q}_m = \sigma_{\alpha\,mk}\,\mathbf{q}_k\,. \tag{36}$$

For this case "covariant derivatives" of transformation spinor matrices may be defined analogously to previous case definitions (26) and (29)

$$U\hat{\overleftarrow{D}}_\alpha \equiv \hat{U}(\overleftarrow{\partial}_\alpha - \hat{A}_\alpha), \quad \hat{D}_\alpha U^{-1} \equiv (\partial_\alpha + \hat{A}_\alpha) U\,. \tag{37}$$

But here the "gauge field" is built from Q-connexion (35)

$$\hat{A}_{k\,\alpha} \equiv \frac{1}{2}\,\varepsilon_{knm}\Omega_{\alpha kn}, \qquad \hat{A}_{\alpha} \equiv \frac{1}{2}\,\hat{A}_n \mathbf{q}_{\tilde{n}}\,. \tag{38}$$

It is not difficult to verify whether the definitions (37) are consistent with non-metricity condition (36). Action of the "covariant derivatives" (37) onto a spinor-transformed unite Q-vector

$$\begin{aligned} &\hat{D}_\alpha \mathbf{q}_k \to (\hat{D}_\alpha U)\,\mathbf{q}_{\tilde{k}}\,\partial_\alpha U^{-1} + U\,\mathbf{q}_{\tilde{k}}\,(\hat{D}_\alpha U^{-1}) = \\ &= \left(U\overleftarrow{D}_\alpha - \frac{1}{4}\,\varepsilon_{jnm}\Omega_{\alpha\,nm} U \mathbf{q}_{\tilde{j}}\,\mathbf{q}_{\tilde{k}} \right) U^{-1} + \\ &+ U\,\mathbf{q}_{\tilde{k}} \left(D_\alpha U^{-1} + \frac{1}{4}\,\varepsilon_{jnm}\Omega_{\alpha\,nm}\,\mathbf{q}_{\tilde{j}}\, U^{-1} \right) \end{aligned}$$

together with Eqs. (26) and (29) demand:

$$U\overleftarrow{D}_\alpha = D_\alpha U^{-1} = 0 \tag{39}$$

leads to the expected results

$$\hat{D}_\alpha \mathbf{q}_k \to \frac{1}{2}\,\varepsilon_{jnm}\sigma_{\alpha\, nm}U\varepsilon_{jkl}\,\mathbf{q}_{\tilde{l}}\,U^{-1} = \\ = \sigma_{\alpha\, kl}\,U\,\mathbf{q}_{\tilde{l}}\,U^{-1} = \sigma_{\alpha\, kl}\,\mathbf{q}_l$$

i.e. "gauge covariant" derivative of any Q-unit results in Q-non-metricity in full accordance with Eq. (36).

Now find curvature tensor components in this Q-space; it is more convenient to calculate them using differential forms. Given Q-connexion 1-form

$$\Omega_{\,kn} = \Omega_{\beta\, kn} dy^\beta \tag{40}$$

from the second equation of structure

$$\frac{1}{2}\,\hat{R}_{kn\alpha\beta}\, dy^\alpha \wedge dy^\beta = d\Omega_{kn} + \Omega_{km} \wedge \Omega_{mn} \tag{41}$$

one gets the curvature tensor component

$$\hat{R}_{kn\alpha\beta} = \partial_\alpha \Omega_{\beta\, kn} - \partial_\beta \Omega_{\alpha\, kn} + \\ + \Omega_{\alpha\, km}\Omega_{\beta\, mn} - \Omega_{\alpha\, nm}\Omega_{\beta\, mk} \tag{42}$$

quite analogously to Eq. (34). Skew-symmetry in 3D indices allows representing the curvature part of 3D Q-section as 3D axial vector

$$\hat{F}_{m\,\alpha\beta} \equiv \frac{1}{2}\,\varepsilon_{knm}\hat{R}_{kn\alpha\beta} \tag{43}$$

and using Eq. (38) one readily rewrites definition (43) in the form

$$\hat{F}_{m\,\alpha\beta} = \partial_\alpha \hat{A}_{m\,\beta} - \partial_\beta \hat{A}_{m\,\alpha} + \varepsilon_{knm}\hat{A}_{k\,\alpha}\hat{A}_{n\,\beta} \tag{44}$$

which exactly coincides with conventional definition (11). QED.

4 Klein-Gordon representation of Yang-Mills field

In the meantime, it is perhaps more interesting to note here that such a neat linkage between Yang-Mills field and quaternion numbers is already known, in particular using Klein-Gordon representation [16]. In turn, this neat correspondence between Yang-Mills field and Klein-Gordon representation can be expected, because both can be described in terms of $\mathrm{SU}(2)$ theory [17]. In this regards, quaternion decomposition of $\mathrm{SU}(2)$ Yang-Mills field has been discussed in [17], albeit it implies a different metric from what is described herein:

$$ds^2 = d\alpha_1^2 + \sin^2\!\alpha_1\, d\beta_1^2 + d\alpha_2^2 + \sin^2\!\alpha_2\, d\beta_2^2\,. \tag{45}$$

However, the $\mathrm{O}(3)$ non-linear sigma model appearing in the decomposition [17] looks quite similar (or related) to the Quaternion relativity theory (as described in the Introduction, there could be neat link between Q-relativity and $\mathrm{SO}(3,1)$).

Furthermore, sometime ago it has been shown that four-dimensional coordinates may be combined into a quaternion, and this could be useful in describing supersymmetric extension of Yang-Mills field [18]. This plausible neat link between Klein-Gordon equation, Duffin-Kemmer equation and Yang-Mills field via quaternion number may be found useful, because both Duffin-Kemmer equation and Yang-Mills field play some kind of significant role in description of standard model of particles [16].

In this regards, it has been argued recently that one can derive standard model using Klein-Gordon equation, in particular using Yukawa method, without having to introduce a Higgs mass [19, 20]. Considering a notorious fact that Higgs particle has not been observed despite more than three decades of extensive experiments, it seems to suggest that an alternative route to standard model of particles using (quaternion) Klein-Gordon deserves further consideration.

In this section we will discuss a number of approaches by different authors to describe the (quaternion) extension of Klein-Gordon equation and its implications. First we will review quaternion quantum mechanics of Adler. And then we discuss how Klein-Gordon equation leads to hypothetical imaginary mass. Thereafter we discuss an alternative route for quaternionic modification of Klein-Gordon equation, and implications to meson physics.

4.1 Quaternion Quantum Mechanics

Adler's method of quaternionizing Quantum Mechanics grew out of his interest in the Harari-Shupe's rishon model for composite quarks and leptons [21]. In a preceding paper [22] he describes that in quaternionic quantum mechanics (QQM), the Dirac transition amplitudes are quaternion valued, i.e. they have the form

$$q = r_0 + r_1 i + r_2 j + r_3 k \tag{46}$$

where r_0, r_1, r_2, r_3 are real numbers, and i, j, k are quaternion imaginary units obeying

$$i^2 = j^2 = k^2 = -1, \quad ij = -ji = k, \\ jk = -kj = i, \qquad ki = -ik = j\,. \tag{47}$$

Using this QQM method, he described composite fermion states identified with the quaternion real components [23].

4.2 Hypothetical imaginary mass problem in Klein-Gordon equation

It is argued that dynamical origin of Higgs mass implies that the mass of W must always be pure imaginary [19, 20]. Therefore one may conclude that a real description for (composite) quarks and leptons shall avoid this problem, i.e. by not including the problematic Higgs mass.

Nonetheless, in this section we can reveal that perhaps the problem of imaginary mass in Klein-Gordon equation is not completely avoidable. First we will describe an elementary derivation of Klein-Gordon from electromagnetic wave equation, and then by using Bakhoum's assertion of total energy we derive alternative expression of Klein-Gordon implying the imaginary mass.

We can start with 1D-classical wave equation as derived from Maxwell equations [24, p.4]:

$$\frac{\partial^2 E}{\partial x^2} - \frac{1}{c^2}\frac{\partial^2 E}{\partial t^2} = 0\,. \tag{48}$$

This equation has plane wave solutions:

$$E(x,t) = E_0 e^{i(kx-\omega t)} \tag{49}$$

which yields the relativistic total energy:

$$\varepsilon^2 = p^2c^2 + m^2c^4. \tag{50}$$

Therefore we can rewrite (48) for non-zero mass particles as follows [24]:

$$\left(\frac{\partial^2}{\partial x^2} - \frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \frac{m^2c^2}{\hbar^2}\right)\Psi e^{\frac{i}{\hbar}(px-Et)} = 0\,. \tag{51}$$

Rearranging this equation (51) we get the Klein-Gordon equation for a free particle in 3-dimensional condition:

$$\left(\nabla - \frac{m^2c^2}{\hbar^2}\right)\Psi = \frac{1}{c^2}\frac{\partial^2\Psi}{\partial t^2}\,. \tag{52}$$

It seems worthnoting here that it is more proper to use total energy definition according to Noether's theorem in lieu of standard definition of relativistic total energy. According to Noether's theorem [25], the total energy of the system corresponding to the time translation invariance is given by:

$$E = mc^2 + \frac{cw}{2}\int_0^\infty \left(\gamma^2\, 4\pi r^2\, dr\right) = k\mu c^2 \tag{53}$$

where k is *dimensionless* function. It could be shown, that for low-energy state the total energy could be far less than $E = mc^2$. Interestingly Bakhoum [25] has also argued in favor of using $E = mv^2$ for expression of total energy, which expression could be traced back to Leibniz. Therefore it seems possible to argue that expression $E = mv^2$ is more generalized than the standard expression of special relativity, in particular because the total energy now depends on actual velocity [25].

From this new expression, it is possible to rederive Klein-Gordon equation. We start with Bakhoum's assertion that it is more appropriate to use $E = mv^2$, instead of more convenient form $E = mc^2$. This assertion would imply [25]:

$$H^2 = p^2c^2 - m_0^2c^2v^2. \tag{54}$$

A bit remark concerning Bakhoum's expression, it does not mean to imply or to interpret $E = mv^2$as an assertion that it implies zero energy for a rest mass. Actually the problem comes from "mixed" interpretation of what we mean with "velocity". In original Einstein's paper (1905) it is defined as "kinetic velocity", which can be measured when standard "steel rod" has velocity approximates the speed of light. But in quantum mechanics, we are accustomed to make use it deliberately to express "photon speed" $= c$. Therefore, in special relativity 1905 paper, it should be better to interpret it as "speed of free electron", which approximates c. For hydrogen atom with 1 electron, the electron occupies the first excitation (quantum number $n = 1$), which implies that their speed also approximate c, which then it is quite safe to assume $E \sim mc^2$. But for atoms with large number of electrons occupying large quantum numbers, as Bakhoum showed that electron speed could be far less than c, therefore it will be more exact to use $E = mv^2$, where here v should be defined as "average electron speed" [25].

In the first approximation of relativistic wave equation, we could derive Klein-Gordon-type relativistic equation from equation (54), as follows. By introducing a new parameter:

$$\zeta = i\,\frac{v}{c}\,, \tag{55}$$

then we can use equation (55) in the known procedure to derive Klein-Gordon equation:

$$E^2 = p^2c^2 + \zeta^2 m_0^2 c^4, \tag{56}$$

where $E = mv^2$. By using known substitution:

$$E = i\hbar\,\frac{\partial}{\partial t}\,, \qquad p = \frac{\hbar}{i}\,\nabla\,, \tag{57}$$

and dividing by $(\hbar c)^2$, we get Klein-Gordon-type relativistic equation [25]:

$$-c^{-2}\,\frac{\partial\Psi}{\partial t} + \nabla^2\Psi = k_0^{'2}\,\Psi\,, \tag{58}$$

where

$$k_0^{'} = \frac{\zeta m_0 c}{\hbar}\,. \tag{59}$$

Therefore we can conclude that imaginary mass term appears in the definition of coefficient $k_0^{'}$ of this new Klein-Gordon equation.

4.3 Modified Klein-Gordon equation and meson observation

As described before, quaternionic Klein-Gordon equation has neat link with Yang-Mills field. Therefore it seems worth to discuss here how to quaternionize Klein-Gordon equation. It can be shown that the resulting modified Klein-Gordon equation also exhibits imaginary mass term.

Equation (52) is normally rewritten in simpler form (by asserting $c = 1$):

$$\left(\nabla - \frac{\partial^2}{\partial t^2}\right)\Psi = \frac{m^2}{\hbar^2}\,. \tag{60}$$

Interestingly, one can write the Nabla-operator above in quaternionic form, as follows:

A. Define quaternion-Nabla-operator as analog to quaternion number definition above (46), as follows [25]:

$$\nabla^q = -i\,\frac{\partial}{\partial t} + e_1\frac{\partial}{\partial x} + e_2\frac{\partial}{\partial y} + e_3\frac{\partial}{\partial z}\,, \qquad (61)$$

where e_1, e_2, e_3 are quaternion imaginary units. Note that equation (61) has included partial time-differentiation.

B. Its quaternion conjugate is defined as follows:

$$\bar{\nabla}^q = -i\,\frac{\partial}{\partial t} - e_1\frac{\partial}{\partial x} - e_2\frac{\partial}{\partial y} - e_3\frac{\partial}{\partial z}\,. \qquad (62)$$

C. Quaternion multiplication rule yields:

$$\nabla^q\,\bar{\nabla}^q = -\frac{\partial^2}{\partial t^2} + \frac{\partial^2}{\partial^2 x} + \frac{\partial^2}{\partial^2 y} + \frac{\partial^2}{\partial^2 z}\,. \qquad (63)$$

D. Then equation (63) permits us to rewrite equation (60) in quaternionic form as follows:

$$\nabla^q\bar{\nabla}^q\Psi = \frac{m^2}{\hbar^2}\,. \qquad (64)$$

Alternatively, one used to assign standard value $c = 1$ and also $\hbar = 1$, therefore equation (60) may be written as:

$$\left(\frac{\partial^2}{\partial t^2} - \nabla^2 + m^2\right)\varphi(x,t) = 0\,, \qquad (65)$$

where the first two terms are often written in the form of square Nabla operator. One simplest version of this equation [26]:

$$-\left(\frac{\partial S_0}{\partial t}\right)^2 + m^2 = 0 \qquad (66)$$

yields the known solution [26]:

$$S_0 = \pm mt + \text{constant}\,. \qquad (67)$$

The equation (66) yields wave equation which describes a particle at rest with positive energy (lower sign) or with negative energy (upper sign). Radial solution of equation (66) yields Yukawa potential which predicts meson as observables.

It is interesting to note here, however, that numerical 1-D solution of equation (65), (66) and (67) each yields slightly different result, as follows. (All numerical computation was performed using Mathematica [28].)

- For equation (65) we get:

(−D[#,x,x]+m^2+D[#,t,t])&[y[x,t]]==

$$m^2 + y^{(0,2)}[x,t] - y^{(2,0)}[x,t] = 0$$

DSolve[%,y[x,t],{x,t}]

$$\left\{\left\{y[x,t] \to \frac{m^2x^2}{2} + C[1][t-x] + C[2][t+x]\right\}\right\}$$

- For equation (66) we get:

(m^2−D[#,t,t])&[y[x,t]]==

$$m^2 + y^{(0,2)}[x,t] = 0$$

DSolve[%,y[x,t],{x,t}]

$$\left\{\left\{y[x,t] \to \frac{m^2t^2}{2} + C[1][x] + tC[2][x]\right\}\right\}$$

One may note that this numerical solution is in quadratic form $\frac{m^2t^2}{2}$ + constant, therefore it is rather different from equation (67) in [26].

In the context of possible supersymetrization of Klein-Gordon equation (and also PT-symmetric extension of Klein-Gordon equation [27, 29]), one can make use biquaternion number instead of quaternion number in order to generalize further the differential operator in equation (61):

E. Define a new "diamond operator" to extend quaternion-Nabla-operator to its biquaternion counterpart, according to the study [25]:

$$\begin{aligned}\diamondsuit = \nabla^q + i\,\nabla^q = \left(-i\frac{\partial}{\partial t} + e_1\frac{\partial}{\partial x} + e_2\frac{\partial}{\partial y} + e_3\frac{\partial}{\partial z}\right) + \\ + i\left(-i\frac{\partial}{\partial T} + e_1\frac{\partial}{\partial X} + e_2\frac{\partial}{\partial Y} + e_3\frac{\partial}{\partial Z}\right),\end{aligned} \qquad (68)$$

where e_1, e_2, e_3 are quaternion imaginary units. Its conjugate can be defined in the same way as before.

To generalize Klein-Gordon equation, one can generalize its differential operator to become:

$$\left[\left(\frac{\partial^2}{\partial t^2} - \nabla^2\right) + i\left(\frac{\partial^2}{\partial t^2} - \nabla^2\right)\right]\varphi(x,t) = -m^2\varphi(x,t), \qquad (69)$$

or by using our definition in (68), one can rewrite equation (69) in compact form:

$$\left(\diamondsuit\bar{\diamondsuit} + m^2\right)\varphi(x,t) = 0, \qquad (70)$$

and in lieu of equation (66), now we get:

$$\left[\left(\frac{\partial S_0}{\partial t}\right)^2 + i\left(\frac{\partial S_0}{\partial t}\right)^2\right] = m^2. \qquad (71)$$

Numerical solutions for these equations were obtained in similar way with the previous equations:

- For equation (70) we get:

(−D[#,x,x]+D[#,t,t]−I*D[#,x,x]+I*D[#,t,t]+m^2)
&[y[x,t]]==

$$m^2 + (1+i)\,y^{(0,2)}[x,t] - (1+i)\,y^{(2,0)}[x,t] = 0$$

DSolve[%,y[x,t],{x,t}

$$\left\{\left\{y[x,t] \to \left(\frac{1}{4} - \frac{i}{4}\right)m^2x^2 + C[1][t-x] + C[2][t+x]\right\}\right\}$$

- For equation (71) we get:

(−m^2+D[#,t,t]+I*D[#,t,t])&[y[x,t]]==

$$m^2 + (1+i)\, y^{(0,2)}[x,t] = 0$$

DSolve[%,y[x,t],{x,t}]

$$\left\{\left\{ y[x,t] \to \left(\frac{1}{4} - \frac{i}{4}\right) m^2 x^2 + C[1][x] + t C[2][x] \right\}\right\}$$

Therefore, we may conclude that introducing biquaternion differential operator (in terms of "diamond operator") yield quite different solutions compared to known standard solution of Klein-Gordon equation [26]:

$$y(x,t) = \left(\frac{1}{4} - \frac{i}{4}\right) m^2 t^2 + \text{constant}\,. \tag{72}$$

In other word: we can infer hat $t = \pm\,\frac{1}{m}\sqrt{y/\left(\frac{1}{4} - \frac{i}{4}\right)}$, therefore it is likely that there is imaginary part of time dimension, which supports a basic hypothesis of the aforementioned BQ-metric in Q-relativity.

Since the potential corresponding to this biquaternionic KGE is neither Coulomb, Yukawa, nor Hulthen potential, then one can expect to observe a new type of matter, which may be called "*supersymmetric-meson*". If this new type of particles can be observed in near future, then it can be regarded as early verification of the new hypothesis of PT-symmetric QM and CT-symmetric QM as considered in some recent reports [27, 29]. In our opinion, its presence may be expected in particular in the process of breaking of Coulomb barrier in low energy schemes.

Nonetheless, further observation is recommended in order to support or refute this proposition.

5 Concluding remarks

If 4D space-time has for its 3D spatial section a Q-space with Q-connexion $\Omega_{\beta\,kn}$ containing Q-non-metricity $\sigma_{\beta\,kn}$, then the Q-connexion, geometric object, is algebraically identical to Yang-Mills potential

$$\hat{A}_{k\alpha} \equiv \frac{1}{2}\,\varepsilon_{knm}\Omega_{\alpha kn}\,,$$

while respective curvature tensor $\hat{R}_{kn\alpha\beta}$, also a geometric object, is algebraically identical to Yang-Mills "physical field" strength

$$\hat{F}_{m\alpha\beta} \equiv \frac{1}{2}\,\varepsilon_{knm}\hat{R}_{kn\alpha\beta}\,.$$

Thus Yang-Mills gauge field Lagrangian

$$L_{YM} \sim \hat{F}^{\alpha\beta}_{k}\hat{F}_{k\alpha\beta} = \frac{1}{4}\,\varepsilon_{kmn}\varepsilon_{kjl}\,\hat{R}^{\alpha\beta}_{mn}\hat{R}_{jl\alpha\beta} = \frac{1}{2}\,\hat{R}^{\alpha\beta}_{mn}\hat{R}_{mn\alpha\beta}$$

can be geometrically interpreted as a Lagrangian of "non-linear" or "quadratic" gravitational theory, since it contains quadratic invariant of curvature Riemann-type tensor contracted by all indices. Hence Yang-Mills theory can be regarded as a theory of pure geometric objects: Q-connexion and Q-curvature with Lagrangian quadratic in curvature (as: Einstein's theory of gravitation is a theory of geometrical objects: Christoffel symbols and Riemann tensor, but with linear Lagrangian made of scalar curvature).

Presence of Q-non-metricity is essential. If Q-non-metricity vanishes, the Yang-Mills potential may still exist, then it includes only proper Q-connexion (in particular, components of Q-connexion physically manifest themselves as "forces of inertia" acting onto non-inertially moving observer); but in this case all Yang-Mills intensity components, being in fact components of curvature tensor, identically are equal to zero.

The above analysis of Yang-Mills field from Quaternion Space geometry may be found useful in particular if we consider its plausible neat link with Klein-Gordon equation and Duffin-Kemmer equation. We discuss in particular a biquaternionic-modification of Klein-Gordon equation. Since the potential corresponding to this biquaternionic KGE is neither Coulomb, Yukawa, nor Hulthen potential, then one can expect to observe a new type of matter. Further observation is recommended in order to support or refute this proposition.

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On the Dependence of a Local-Time Effect on Spatial Direction

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This paper addresses further investigations of local-time effects on the laboratory scale. We study dependence of the effect on spatial directions defined by a pair of sources of fluctuations. The results show that the effect appears in the neighborhood of directions North-South and East-West. Only for these directions are the experimental results in excellent agreement with theoretically predicted local-time values. The results reveal the character of near-Earth space heterogeneity and lead to the conclusion that at the laboratory scale, local-time effects cannot be caused by some axial-symmetric structure, which has permanent properties along an Earth meridian. Appearance of the effect along an Earth parallel is linked to rotational motion of the Earth. Observed properties of local-time effects in the direction of an Earth meridian can be linked to motion of the Earth in this direction.

1 Introduction

The results of many years of investigation of macroscopic fluctuation phenomena can be considered as evidence of an essential heterogeneity and anisotropy of space-time. This statement is based upon the results of studies of α-decay-rate fluctuations of ^{239}Pu sources measured by plane semiconductor detectors and detectors with collimators cutting α-particle beams, carried out in the years 1985–2005 [1–6]. For reasons of methodology, the time resolution reached in those years was about one minute, and the studied spatial scale about a hundred kilometers. This work presents results of further investigations of macroscopic fluctuations phenomena with time resolution to 0.5 milliseconds.

Such resolution allows studies of local time effects for distances down to one metre between sources of fluctuations [7, 8]. On the one hand, this result has an independent importance as a lower scale end for the existence of macroscopic fluctuations phenomena, but on the other hand, it has great methodological importance due to the possibility of systematic laboratory investigations, which were previously unavailable because of very large spatial distances between places of measurement. One such investigation is the dependence of local-time effects as function of spatial directions, which is the main subject of this paper.

2 Experiment description and results

A functional diagram of the experimental setup is presented in Fig. 1b). It consists of two sources of fluctuations, which are fixed to a wooden base. The distance between the sources was 1.36 m. The base, with the sources of fluctuations, can revolve on its axis and can be positioned in any desired direction. A two-channel LeCroy WJ322 digital storage oscilloscope (DSO in Fig. 1b) was used for data acquisition.

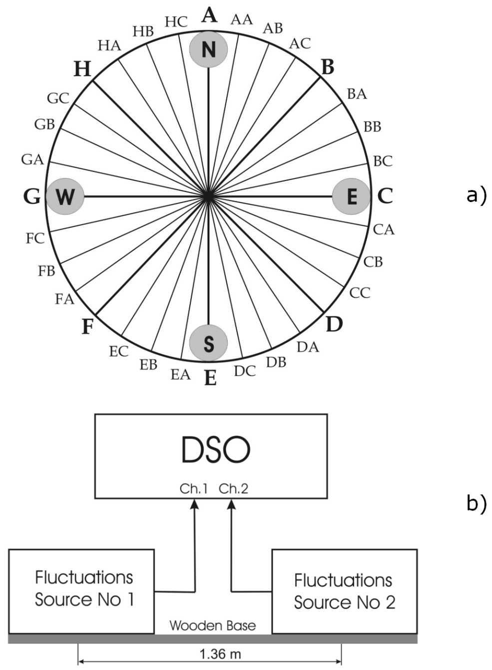

Fig. 1: Diagram of spatial directions, which was examined in experiments with fixed spatial base 1.36 m (a) and functional diagram of the experimental setup (b).

The digitizing frequency used for all series of measurements was 100 kHz. Consequently, the duration of 50-point histograms, which were used in the experiment, is 0.5 milliseconds. This means that all local-time values in the experiment are defined with an accuracy of ± 0.5 milliseconds.

Fig. 1a) depicts the spatial directions which were examined in the experiment. In Fig. 1a) every one of these directions is denoted by letters outside the circle. For example, direction AA means that the base with the sources of fluctuations is

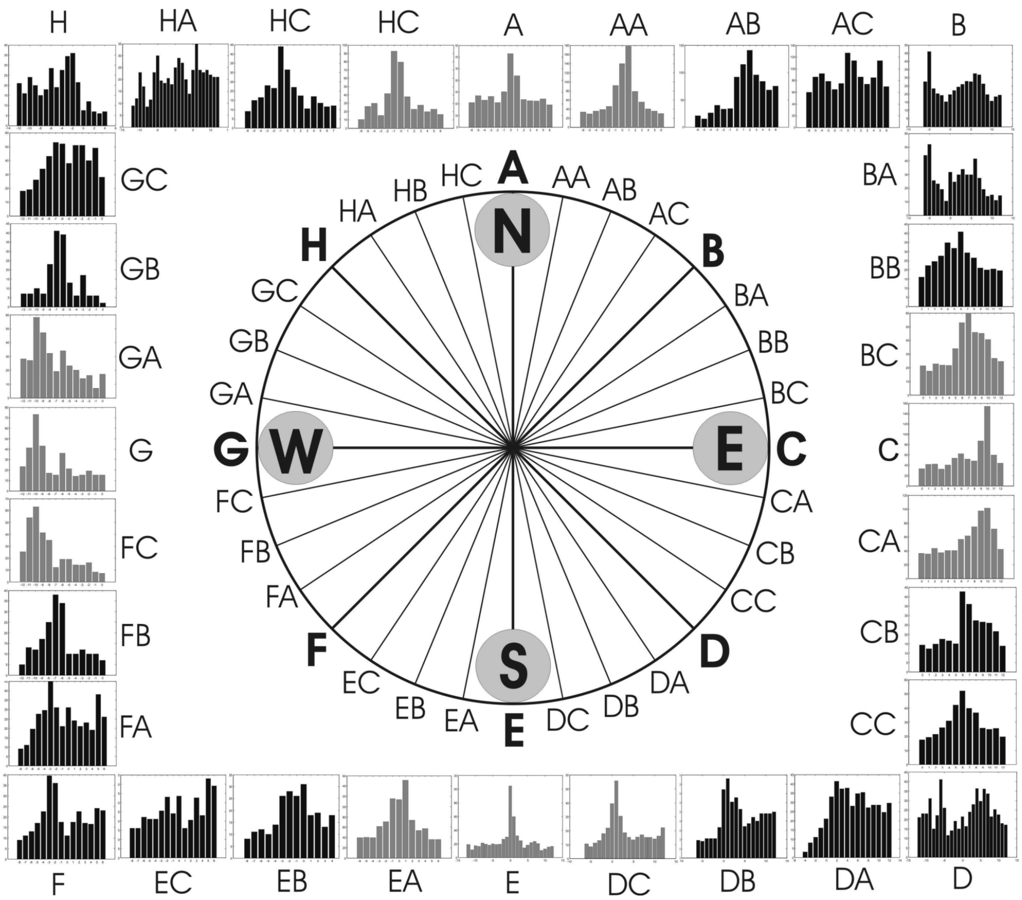

Fig. 2: Averaged interval distributions obtained for every spatial direction.

aligned in the EA-AA direction in such a way that source No 1 is placed on the AA end of the base and source No 2 is placed on the EA end. Correspondingly, direction EA means that source No 1 is on the EA end, and source No 2 is on the opposite end. Letters N, S, E, and W denote directions to the North, South, East, and West respectively. Directions A and E lie on an Earth meridian, and directions G and C lie on an Earth parallel.

The angular difference between two neighboring directions is 11.25°, so we have 32 spatial directions. To examine all the directions one series of measurements must include 32 pairs of synchronous records. Every record consists of 500,000 points. This allowed acquisition of two synchronous sets of 50-point histograms for every direction. Every set contains 10,000 histograms. The experimental results, which are presented below, are based on 8 series of measurements.

It is important to note that pairs of directions presented in Fig. 1a), for example, A-E and E-A, are actually the same because the pair of fluctuations sources used in the experiment are non-directional. For this reason the total number of directions examined is half that denoted by letters in Fig. 1a). The second measurement in an opposite pair of directions can be considered as a control. The data processing procedure used in the experiment is described in detail in [2, 9].

Fig. 2 shows the interval distributions obtained for each of the 32 spatial directions. Every one of these distributions is averaged through the interval distributions from all of the series of measurements for every one of the spatial directions. The circle inside Fig. 2 is the same as in Fig. 1a) and shows spatial directions in relation to the presented interval distributions.

All the distributions presented in Fig. 2 can be divided into two distinct groups. The first group consists of distributions in the neighbourhoods (approximately $\pm 11.25°$ of the directions A-E and C-G; labeled as A, E, C, and G. To the first group also can be related distributions that are closest to A, E, C, and G: HC, AA, BC, CA, DC, EA, FC, GA. To the second group can be related all remaining distributions. The distribution from the first group we call 'non-diagonal', and from the second, 'diagonal'. The first group in Fig. 2 is highlighted by the gray color.

The main difference between the two groups lies in the following: non-diagonal distributions always have a single peak, which corresponds to the same interval value in all series of measurements. In the case of the non-diagonal distributions, every spatial direction can be characterized by a

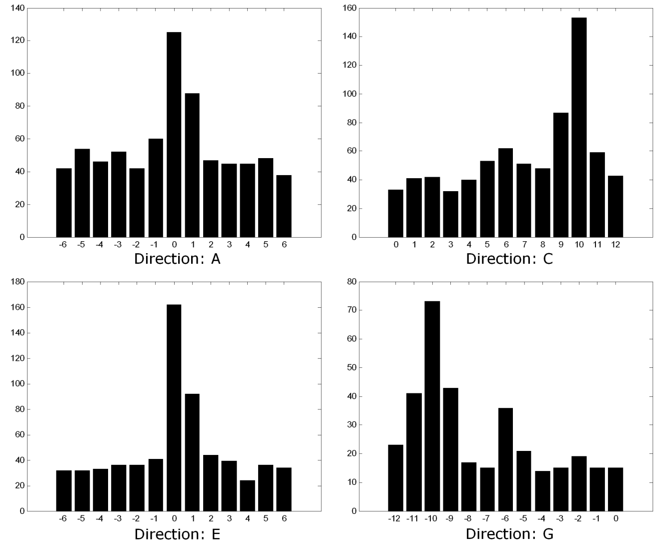

Fig. 3: Non-diagonal interval distributions for meridian (North-South) directions A and E, and for parallel (East-West) directions C and G.

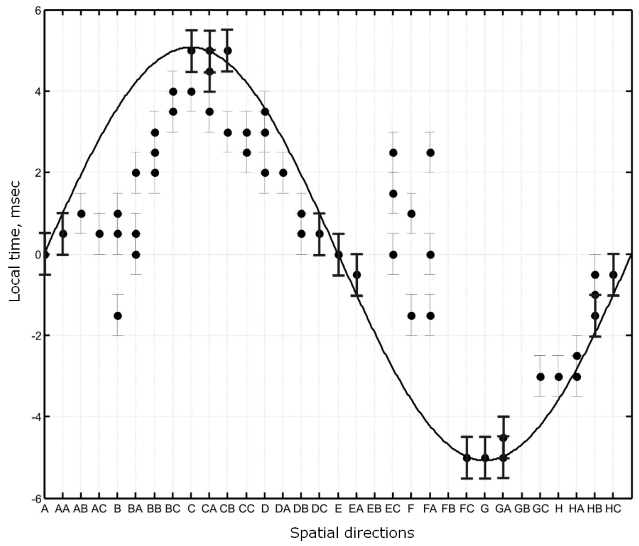

Fig. 4: Theoretical estimation (solid line) and experimentally obtained local-time values. Points with bold error bars show local-time values for non-diagonal directions.

stable, reproducible pattern of interval distribution. Contrary to non-diagonal distributions, a diagonal distribution is multi-peaked and cannot ordinarily be characterized by a stable, reproducible pattern.

Non-diagonal interval distributions are presented in Fig. 3. For Earth meridian directions (A and E), patterns of interval distributions always have a stable peak at zero intervals. In the case of Earth parallel directions (C and G), interval distributions have a peak at the interval that is equal to the local-time-difference for the spatial base of 1.36 m. This difference has the same magnitude but different sign for opposite directions. It is easy to see from Fig. 3 that interval distributions for directions C and G have peaks at the intervals 10 and -10.

3 Value of local-time-difference

As follows from previous investigations [1–6] the value of the local-time effect depends only on the longitudinal difference between places of measurements, not on latitudinal distance. From this it follows that the factor which determines the shape of fine structure of histograms must be axial-symmetric. Longitudinal dependence of local-time effect phenomenology can be considered as dependence of shape of the fine structure of histograms on spatial directions defined by the centre of the Earth and the two points where measurements are taken [8]. In this case the results of measurements depend on the solid angle between two planes defined by the axis of the Earth and the two points of measurement; such angle depends on the longitudinal difference, not on the latitudinal difference.

But for the case of separated measurements with fixed spatial base $\triangle L_0 = \text{const}$, the results of the experiment become dependent on latitude, θ. Really, the time $\triangle t$, after which fluctuation source No 2 will define the same direction as source No 1 before, depends on the velocity of the measurement system $\nu(\theta, h)$:

$$\triangle t = \frac{\triangle L_0}{\nu(\theta, h)} \sin\alpha \,, \qquad (1)$$

where $\alpha \in [0, 2\pi]$ is an angle, counter-clockwise from the direction to the North (direction A). It is important to note that the theoretical estimation of the longitudinal difference is given by (1) obtained on the assumption that the factor determining the fine structure of histograms is axial-symmetric.

The value $\nu(\theta, h)$ is determined by:

$$\nu(\theta, h) = \frac{2\pi}{T}\left(\sqrt{\frac{R_p^2}{\frac{R_p^2}{R_e^2} + \tan^2\theta}} + h\right), \qquad (2)$$

where $R_p = 6356863$ m and $R_e = 6378245$ m are the values of the polar and equatorial radii of the Earth [10] respectively, $T = 86160$ sec is the period of the Earth's revolution. For the place of measurements (Pushchino, Moscow region) we have latitude $\theta_p = 54°50.037'$ and height above sea level $h_p = 170$ m. So the velocity of the measurement system is $\nu(\theta_p, h_p) = 268$ m/sec. For near-equatorial regions $\nu(\theta, h)$ can exceed $\nu(\theta_p, h_p)$ by almost twice the latter. Consequently, for measurements with a fixed spatial base we have sufficiently strong dependence of local-time-difference (1) on latitude θ.

The value of the velocity $\nu(\theta_p, h_p)$ allows, on the basis of (1), calculation of the local-time-difference $\triangle t(\alpha)$ as function of spatial directions examined in the experiment. The solid line in Fig. 4 shows the results of this calculation.

Points with error bars in Fig. 4 show local-time values obtained for all series of measurements.

4 Discussions

It is easy to see from Fig. 4 that the experimental results are in excellent agreement with the theoretically predicted local-time values only for a narrow neighbourhood around the directions North-South (directions A and E) and East-West (directions C and G) i.e. for non-diagonal directions. At the same time, for diagonal directions, the experimental results in most cases don't follow the theoretical predictions. Results presented in Fig. 4 are in agreement with results summarized in Fig. 2, and linked to the dependence of local-time effect on spatial directions.

The results reveal the character of near-Earth space anisotropy. As pointed out above, the theoretical estimation of local-time effect values in Fig. 4 were obtained under the hypothesis that the effect is caused by some axial-symmetric structure, which has permanent properties along an Earth meridian. According to this hypothesis, the dependence of local-time effect must be the same for all spatial directions, and local-time values obtained in the experiment must follow the theoretically predicted values. But the fact that the diagonal directions experimental results don't confirm this hypothesis leads to the conclusion that at the laboratory scale local-time effects cannot be caused by some axial-symmetric structure.

Evidently, dependence of local-time effects in East-West directions is linked to the rotational motion of the Earth. In this case, after the time interval $\triangle t$, which is equal to local-time difference for the spatial base used, the position of the 'West' source of fluctuations will be exactly the same as the position of 'East' previously. In the case of diagonal spatial directions such a coincidence is absent. However, for North-South direction such an explanation is inapplicable.

Dependence of the local-time effect in the direction of a meridian is probably linked to the velocity component along the path of the Solar System in the Galaxy. This hypothesis is preliminary and may possibly change in consequence of future investigations.

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A Study of a Local Time Effect on Moving Sources of Fluctuations

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This work presents an experimental investigation of a possible mechanism causing local time effects, with the aid of moving sources of fluctuations. The results show that the measurement system, consisting of two separated sources of fluctuations moving in a near-Earth space, can detect its own motion in form of a local time effect, or in other words, we can determine uniform and rectilinear motion of an isolated system on the basis of measurements made inside the system.

1 Introduction

If at any two places on the Globe we make two synchronous records of fluctuations in any natural processes, then by a standard method [1-4] we can find that shape of the fine structure of histograms, constructed on the basis of short segments of time series, is most similar for such pairs, that are separated by a time interval equal to the local time difference for the places of measurements. Because of this the phenomenon is called the local time effect. At the present time it is known that the effect exists for any distances between places of measurements, ranging from the highest possible on the Earth down to one metre [5, 6]. The local time or longitudinal difference implies dependence of the fine structure of the histograms on the Earth's rotation around its axis. In relation to ambient space this means that after a time interval equal to the local time difference measurement, system No. 2 appears in the same place where system No. 1 was located previously, or that measurement system No. 2 will be oriented in the same direction as system No. 1 was oriented before. The same places or directions mean that the same conditions prevail and, consequently, a similar shape for the histograms.

The existence of a local time effect is closely connected with space-time heterogeneity. Really the effect is possible only if the experimental setup, consisting of a pair of separated sources of fluctuations, moves through heterogeneous invariable space. It is obvious that for the case of homogeneous space the effect cannot exist. Existence of a local-time effect for some space scale can be considered as evidence of space-time heterogeneity, which corresponds to this scale.

So, to observe the local time effect we need *heterogeneous invariable* space and a pair of fluctuation sources on a fixed spatial base, which *moves synchronously* through that space. All phenomenology of the local time effect was obtained due to rotational motion of the Earth. The present investigation studies the local time effect for the case of the measurement system moving independently of the rotational motion of the Earth. In other words, we try to ascertain if an isolated measurement system, consisting of two separated sources of fluctuations, can detect its own motion in the form of a local time effect.

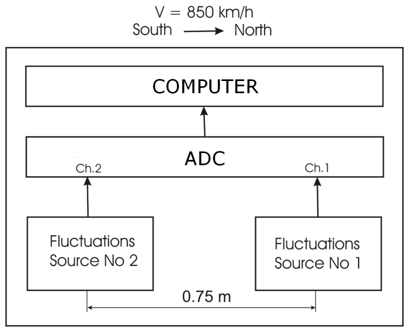

Fig. 1: Simplified diagram of the experiment with moving sources of fluctuations.

2 Experiment description and results

A simplified diagram of the experiment with moving sources of fluctuations is presented in Fig. 1. The measurement system consists of two separated sources of fluctuations, which are oriented in the line of the velocity vector of the plane in such a way that source No. 2 follows source No. 1. The sources are separated by the fixed distance of 0.75 m. Signals of fluctuations were digitized by means of an analogue-to-digital converter (ADC) via a USB interface connected to a personal computer running appropriate data acquisition software. The whole system was mounted inside the plane moving with a velocity of $V = 850$ km/h along an Earth meridian from South to North.

The digitizing frequency used for all series of measurements was 100 kHz. One record consists of 500 kpts per channel. This allowed acquisition of two synchronous sets of 50-point histograms. The maximum length of each set was 10,000 histograms. Consequently, the duration of a 50-point histogram is 0.5 ms, so that all local-time values in the experiment can be determined to an accuracy of ± 0.5 ms.

The local time value $\triangle t$ for the experiment is the time

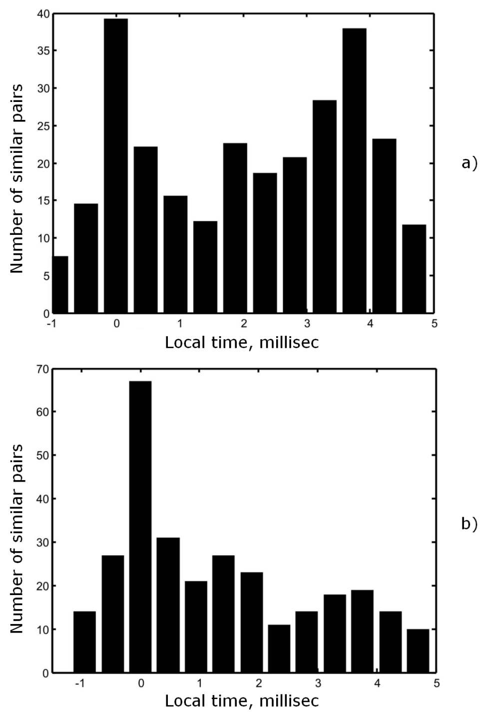

Fig. 2: a) Interval distributions for moving, and b) motionless ground-based measurement systems. Measurements were carried out at the same time each day and at the same spatial orientation of the measurement systems (South-North).

interval in which the plane can travel a distance of 0.75 m. Calculation shows that this value is $\triangle t = 3.18$ ms.

Along with the moving experiment, a motionless ground-based one was carried out. For this experiment we used the same experimental setup and exactly the same orientation of fluctuation sources. The motionless measurements were carried out at the same daytime as for measurements with the moving system.

The intervals distribution for the motionless ground-based experiment is presented in Fig. 2b). The distribution has a single peak at the zero interval. The pattern of this distribution is exactly the same as that reported in work [7] for a meridian direction.

The interval distribution for the moving measurement system is shown in Fig. 2a). Like the distribution in Fig. 2b), in this case we also have zero-peak, except this peak on the distribution has a maximum at 3.5 ± 0.5 ms, which is in good agreement with the calculated local time value $\triangle t = 3.18$ ms and can be linked to motion of the measurement system.

Both interval distributions presented in Fig. 2 represent an average of five series of measurements. Ordinates in Fig. 2 are defined to 7–10%.

3 Conclusions

The results confirm the hypothesis that a local time effect is caused by motion of the measurement system in heterogeneous invariable space. The opposite statement also is true: a measurement system moving in near-Earth space can detect its own motion in the form of a local time effect. It is interesting to note that by means of the method described above, it is possible to determine uniform and rectilinear motion of an isolated system on the basis of measurements made inside the system.

The zero-peak for both interval distributions in Fig. 2, aren't linked to plane motion and are caused only by the spatial orientation of the measurement system [7]. Investigation of the nature of the zero-peak is one of our immediate tasks.

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SPECIAL REPORT

A Theory of the Podkletnov Effect based on General Relativity: Anti-Gravity Force due to the Perturbed Non-Holonomic Background of Space

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We consider the Podkletnov effect — the weight loss of an object located over a superconducting disc in air due to support by an alternating magnetic field. We consider this problem using the mathematical methods of General Relativity. We show via Einstein's equations and the geodesic equations in a space perturbed by a disc undergoing oscillatory bounces orthogonal to its own plane, that there is no rôle of superconductivity; the Podkletnov effect is due to the fact that the field of the background space non-holonomity (the basic non-othogonality of time lines to the spatial section), being perturbed by such an oscillating disc produces energy and momentum flow in order to compensate the perturbation in itself. Such a momentum flow is directed above the disc in Podkletnov's experiment, so it works like negative gravity (anti-gravity). We propose a simple mechanical system which, simulating the Podkletnov effect, is an experimental test of the whole theory. The theory allows for other "anti-gravity devices", which simulate the Podkletnov effect without use of very costly superconductor technology. Such devices could be applied to be used as a cheap source of new energy, and could have implications to air and space travel.

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1 Introducing Podkletnov's experiment

In 1992, Eugene Podkletnov and his team at the Tampere Institute of Technology (Finland) tested the uniformity of a unique bulky superconductor disc, rotating at high speed via a magnetic field [1]. The 145×6-mm superconductor disc was horizontally oreinted in a cryostat and surrounded by liquid helium. A small current was initiated in the disc by outer electromagnets, after which the medium was cooled to 20–70 K. As the disc achieved superconductivity, and the state became stable, another electromagnet located under the cryostat was switched on. Due to the Meissner-Ochsenfeld effect the magnetic field lifted the disc into the air. The disc was then driven by the outer electromagnets to 5000 rpm.

A small non-conducting and non-magnetic sample was suspended over the cryostat where the rotating disc was contained. The weight of the sample was measured with high precision by an electro-optical balance system. "The sample with the initial weight of 5.47834 g was found to lose about 0.05% of its weight when placed over the levitating disc without any rotation. When the rotation speed of the disc increased, the weight of the sample became unstable and gave fluctuations from -2.5 to $+5.4$% of the initial value. [. . .] The levitating superconducting disc was found to rise by up to 7 mm when its rotation moment increased. Test measurements without the superconducting shielding disc but with all operating solenoids connected to the power supply, had no effect on the weight of the sample" [1].

Additional results were obtained by Podkletnov in 1997, with a larger disc (a $275/80\times10$-mm toroid) run under

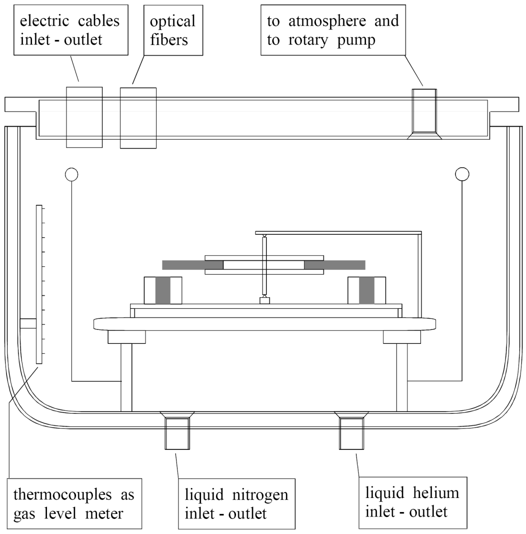

Fig. 1: Cryogenic system in Podkletnov's experiment [2]. Courtesy of E. Podkletnov. Used by permission.

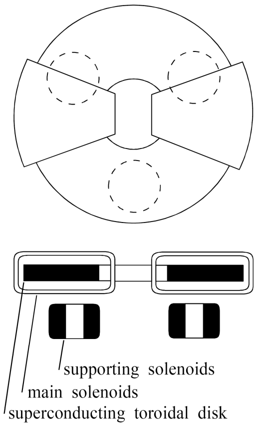

Fig. 2: Supporting and rotating solenoids in Podkletnov's experiment [2]. Courtesy of E. Podkletnov. Used by permission.

similar conditions [2]: "The levitating disc revealed a clearly measurable shielding effect against the gravitational force even without rotation. In this situation, the weight-loss values for various samples ranged from 0.05 to 0.07%. [. . .] Samples made from the same material and of comparable size, but with different masses, lost the same fraction of their weight. [. . .] Samples placed over the rotating disc initially demonstrated a weight loss of 0.3–0.5%. When the rotation speed was slowly reduced by changing the current in the solenoids, the shielding effect became considerably higher and reached 1.9–2.1% at maximum" [2].

Two groups of researchers supported by Boeing and NASA, and also a few other research teams, have attempted to replicate the Podkletnov experiment in recent years [3–7]. The main problem they encountered was the reproduction of the technology used by Podkletnov in his laboratory to produce sufficiently large superconductive ceramics. The technology is very costly: according to Podkletnov [8] this re-

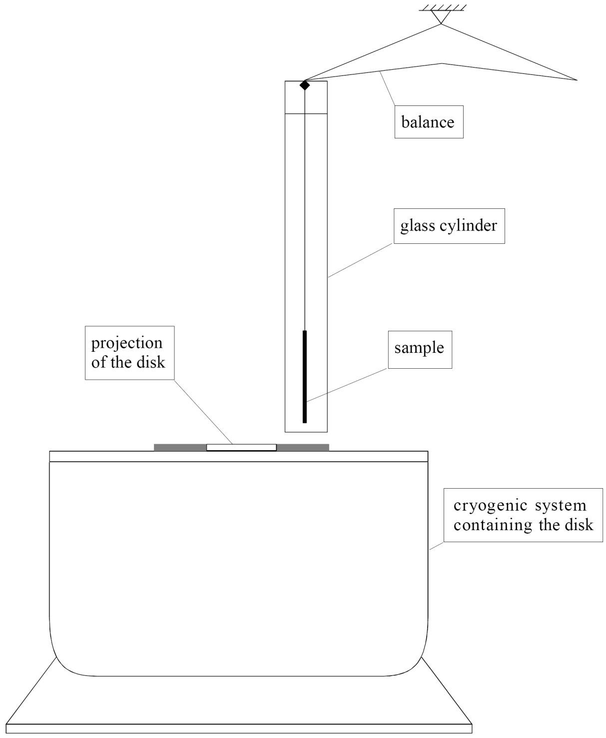

Fig. 3: Weight and pressure measurement in Podkletnov's experiment [2]. Courtesy of E. Podkletnov. Used by permission.

quires tens of millions of dollars. Therefore the aforementioned organisations tested discs of much smaller size, about 1″ diameter; so they produced controversial results at the boundary of precision measurement. As was pointed out by Podkletnov in his recent interview (April, 2006), the NASA team, after years of unsuccessful attempts, made a 12″ disc of superconductive ceramic. However, due to the crude internal structure (this is one of the main problems in making such discs), they were unable to use the disc to replicate his experiment [8].

Podkletnov also recently reported on a "gravity field generator" [8, 9] constructed in his laboratory in recent years, on the basis of the earlier observed phenomenon.

In a nutshell, the aforementioned phenomenon is as follows. We will refer to this as the *Podkletnov effect*:

> When a disc of superconductive ceramic, being in the state of superconductivity, is suspended in air by an alternating magnetic field due to an electromagnet located under the disc, the disc is the source of a radiation. This radiation, traveling like a plane wave above the disc, acts on other bodies like a negative gravity. The radiation becomes stronger with larger discs, so it depends on the disc's mass and radius. When the disc rotates uniformly, the radiation remains the same. During acceleration/braking of the disc's rotation, the radiation essentially increases.

Podkletnov claimed many times that he discovered the effect by chance, not by any theoretical prediction. Being an experimentalist who pioneered this field of research, he continued his experiments blindfolded: in the absence of a theoretical reason, the cause of the observed weight loss was unclear. This is why neither Podkletnov nor his followers at Boeing and NASA didn't develop a new experiment by which the weight loss effect substantially increased.

For instance, Podkletnov still believes that the key to his experiment is that special state which is specific to the electron gas inside superconductive materials in the state of superconductivity [8]. He and all the others therefore focused attention on low temperature superconductive ceramics, production of which, taking the large size of the discs into account, is a highly complicated and very costly process, beyond most laboratories. In fact, during the last 15 years only Podkletnov's laboratory has had the ability to produce such the discs with sufficient quality.

We propose a purely theoretical approach to this problem. We consider Podkletnov's experiment using the mathematical methods of General Relativity, in the Einstenian sense: we represent all essential components of the experiment as a result of the geometrical properties of the laboratory space such as the space non-uniformity, rotation, deformation, and curvature. We build a complete theory of the Podkletnov effect on the basis of General Relativity.

By this we will see that there is no rôle for superconductivity; Podkletnov's effect has a purely mechanical origin due in that the vertical oscillation of the disc, produced by the supporting alternating magnetic field, and the angular acceleration/braking of the disc's rotation, perturb a homogeneous field of the basic non-holonomity of the space (the basic non-othogonality of time lines to the spatial section, known from the theory of non-holonomic manifolds). As a result the non-holonomity field, initially homogeneous, is locally stressed, which is expressed by a change of the left side of Einstein's equations (geometry) and, through the conservation law, a corresponding change of the right side — the energy-momentum tensor for distributed matter (the alternating magnetic field, in this case). In other words, the perturbed field of the space non-holonomity produces energy-momentum in order to compensate for the local perturbation in itself. As we will see, the spatial momentum is directed above the disc in Podkletnov's experiment, so it works like negative gravity.

Owing to our theory we know definitely the key parameters ruling the weight loss effect. Therefore, following our calculation, it is easy to propose an experiment wherein the weight loss substantially increases.

For example, we describe a new experiment where the Podkletnov effect manifests via simple electro-mechanical equipment, without costly superconductor technology. This new experiment can be replicated in any physics laboratory.

We therefore claim thta with our mathematical theory of the Podkletnov effect, within the framework of General Relativity, we can calculate the factors ruling the weight loss. This gives us an opportunity to construct actual working devices which could revolutionize air and space travel. Such new technology, which uses high frequency electromagnetic generators and mechanical equipment instead of costly superconductors, can be the subject of further research on a commercial basis (due to the fact that applied research is outside academia).

Besides, additional energy-momentum produced by the space non-holonomity field in order to compensate for a local perturbation in itself, means that the Podkletnov effect can be used to produce new energy.

By our advanced study (not included in this paper), of our mathematical theory, that herein gives the key factors which rule the new energy, lends itself to the construction of devices which generate the new energy, powered by strong electromagnetic fields, not nuclear reactions and atomic fuel. Therefore this technology, free of radioactive waste, can be a source of clean energy.

2 The non-holonomic background space

2.1 Preliminary data from topology

In this Section we construct a space metric which includes a basic (primordial) non-holonomity, i.e. a basic field of the non-orthogonality of the time lines to the three-dimensional spatial section.

Here is some information from topology Each axis of a Euclidean space can be represented as the element of a circle with infinite radius [10]. An n-dimensional torus is the topological product of n circles. The volume of an n-dimensional torus is completely equivalent to the surface of an $(n+1)$-dimensional sphere. Any compact metric space of n dimensions can be mapped homeomorphicly into a subset of a Euclidean space of $2n+1$ dimensions.

Sequences of stochastic transitions between configurations of different dimensions can be considered as stochastic vector quantities (fields). The extremum of a distribution function for frequencies of the stochastic transitions dependent on n gives the most probable number of the dimensions, and, taking the mapping $n \to 2n+1$ into account, the most probable configuration of the space. This function was first studied in the 1960's by di Bartini [11, 12, 13]. He found that the function has extrema at $2n+1 = \pm 7$ that is equivalent to a 3-dimensional vortical torus coaxial with another, the same vortical torus, mirrored with the first one. Each of the torii is equivalent to a (3+1)-dimensional sphere. Its configuration can be easy calculated, because such formations were studied by Lewis and Larmore. A vortical torus has no breaks if the current lines coincide with the trajectory of the vortex core. Proceeding from the continuity condition, di Bartini found the most probable configuration of the vortical torus is it characterized by the ratio $E = \frac{D}{r} = \frac{1}{4} e^{6.9996968} = 274.074996$ between the torus diameter D and the radius of torus circulation r.

We apply di Bartini's result from topology to General Relativity. The time axis is represented as the element of the circle of radius $R=\frac{1}{2}D$, while the spatial axes are the elements of three small circles of radii r (the topological product of which is the 3-dimensional vortical torus). In a "metric" representation by a Minkowski diagram, the torus is a 3-dimensional spatial section of the given (3+1)-space while the time lines have some *inclination* to the the spatial section. In order for the torus (the 3-dimensional space of our world) to be uniform without break, all the time lines have the *same inclination* to the spatial section at each point of the section.

Cosines of the angles between the coordinate axes, in Riemannian geometry, are represent by the components of the fundamental metric tensor $g_{\alpha\beta}$ [14]. If the time lines are everywhere orthogonal to the spatial section, all g_{0i} are zero: $g_{0i}=0$. Such a space is called *holonomic*. If not ($g_{0i}\neq 0$), the space is said to be *non-holonomic*. As was shown in the 1940's by Zelmanov [15, 16, 17], a field of the space non-holonomity (inclinations of the time lines to the spatial section) manifests as a rotation of the space with a 3-dimensional velocity $v_i=-\frac{c\,g_{0i}}{\sqrt{g_{00}}}$. The mathematical proof is given in Appendix 1.

So a field with the same inclination of the time lines to the spatial section is characterized, in the absence of gravitational fields, by $v_i=-c\,g_{0i}=\text{const}$ at each point of the spatial section. In other words, this is a field of the *homogeneous non-holonomity* (rotation) of the whole space. It is hard to explain such a field by everyday analogy, because it has zero angular speed, and also no centre of rotation. However owing to the space-time representation by a Minkowski diagram, it appears very simply as a field of which the time arrows pierce the hyper-surface of the spatial section with the same inclination at each point.

After di Bartini's result, we therefore conclude that the most probable configuration of the basic space (space-time) of General Relativity is represented by a primordially non-holonomic (3+1)-dimensional pseudo-Riemannian space, where the non-holonomic background field is homogeneous, which manifests in the spatial section (3-dimensional space) as the presence of two fundamental drift-fields:

1. A homogeneous field of the constant linear velocity of the background space rotation
$$\bar{v}=c\,\frac{r}{R}=\frac{2c}{E}=\text{const}=2.187671\times10^{8}\ \text{cm/sec} \tag{1}$$
which originates from the fact that, given the non-holonomic space, the time-like spread R depends on the spatial-like spread r as $\frac{R}{r}=\frac{1}{2}E=137.037498$. The background space rotation, with $\bar{v}=2{,}187.671$ km/sec at each point of the space, is due to the continuity condition everywhere inside the torus;
2. A homogeneous drift-field of the constant dipole-fit linear velocity
$$\bar{\text{v}}=\frac{\bar{v}}{2\pi}=\text{const}=3.481787\times10^{7}\ \text{cm/sec} \tag{2}$$
which characterizes a spatial linear drift of the non-holonomic background relative to any given observer. The field of the spatial drift with $\bar{\text{v}}=348.1787$ km/sec is also present at each point of the space.

In the spatial section the background space rotation with $\bar{v}=2{,}187.671$ km/sec is observed as absolute motion. This is due to the fact that a rotation due to the space non-holonomity is relative to time, not the spatial coordinates. Despite this, as proven by Zelmanov [15, 16, 17], such a rotation relates to spatial rotation, if any.

2.2 The space metric which includes a non-holonomic background

We are going to derive the metric of a non-holonomic space, which has the aforementioned most probable configuration for the (3+1)-space of General Relativity. To do this we consider an element of volume of the space (the elementary volume).

We consider the pseudo-Riemannian (3+1)-space of General Relativity. Let it be non-holonomic so that the non-holonomity field is homogeneous, i.e. manifests as a homogeneous space-time rotation with a linear velocity v, which has the same numerical value along all three spatial axes at each point of the space. The elementary 4-dimensional interval in such a space is

$$ds^2=c^2dt^2+\frac{2v}{c}\,cdt\,(dx+dy+dz)-\\-dx^2-dy^2-dz^2, \tag{3}$$

where the second term is not reduced, for clarity.

We denote the numerical coefficient, which characterize the space rotation (see the second term on the right side), as $\alpha=v/c$. We mean, consider the most probable configuration of the (3+1)-space, $v=\bar{v}=2{,}187.671$ km/sec and also $\alpha=\bar{v}/c=1/137.037498$. The ratio $\alpha=\bar{v}/c$ specific to the space (it characterizes the background non-holonomity of the space), coincides with the analytical value of Sommerfeld's fine-structure constant [11, 12, 13], connected to electromagnetic interactions.*

Given the most probable configuration of the space, each 3-dimensional volume element rotates with the linear velocity $\bar{v}=2{,}187.671$ km/sec and moves with the velocity $\bar{\text{v}}=\frac{\bar{v}}{2\pi}=348.1787$ km/sec relative toward any observer located in the space. The metric (3) contains the space rotation only. To modify the metric for the most probable configura-

*Tests based on the quantum Hall effect and the anomalous magnetic moment of the electron, give different experimental values for Sommerfeld's constant, close to the analytical value. For instance, the latest tests (2006) gave $\alpha\simeq 1/137.035999710(96)$ [18].

$$
\begin{aligned}
ds^2 = c^2dt^2 + \frac{2v\,(\cos\varphi+\sin\varphi)}{c}\,cdt\,dr + \frac{2vr\,(\cos\varphi-\sin\varphi)}{c}\,cdt\,d\varphi + \frac{2v}{c}\,cdt\,dz - \\
- dr^2 + \frac{2v\mathrm{v}\,(\cos\varphi+\sin\varphi)}{c^2}\,dr\,dz - r^2d\varphi^2 + \frac{2v\mathrm{v}r\,(\cos\varphi-\sin\varphi)}{c^2}\,d\varphi\,dz - dz^2
\end{aligned}
\tag{7}
$$

tion, we should apply Lorentz' transformation along the direction of the space motion.

We choose the z-axis for the direction of space motion. For clarity of further calculation, we use the cylindrical coordinates r, φ, z

$$x = r\cos\varphi\,, \qquad y = r\sin\varphi\,, \qquad z = z\,, \tag{4}$$

so the metric (3) in the new coordinates takes the form

$$
\begin{aligned}
ds^2 &= c^2dt^2 + \frac{2v}{c}\,(\cos\varphi+\sin\varphi)\,cdt\,dr + \\
&+ \frac{2vr}{c}\,(\cos\varphi-\sin\varphi)\,cdt\,d\varphi + \frac{2v}{c}\,cdt\,dz - \\
&- dr^2 - r^2d\varphi^2 - dz^2.
\end{aligned}
\tag{5}
$$

Substituting the quantities $\tilde{t}$ and $\tilde{z}$ of Lorentz' transformations

$$\tilde{t} = \frac{t + \frac{\mathrm{v}z}{c^2}}{\sqrt{1-\frac{\mathrm{v}^2}{c^2}}}\,, \qquad \tilde{z} = \frac{z + \mathrm{v}t}{\sqrt{1-\frac{\mathrm{v}^2}{c^2}}}\,, \tag{6}$$

for t and z in the metric (5), we obtain the metric for a volume element which rotates with the constant velocity $\bar{v} = \alpha c$ and approaches with the constant velocity $\mathrm{v} = \bar{\mathrm{v}}$ with respect to any observer located in the space. This is formula (7) shown on the top of this page. In that formula

$$\frac{1}{\sqrt{1-\frac{\mathrm{v}^2}{c^2}}} = \frac{1}{\sqrt{1-\frac{\bar{\mathrm{v}}^2}{c^2}}} = \text{const} \simeq 1\,, \tag{8}$$

due to that fact that, in the framework of this problem, $\mathrm{v} \ll c$. Besides there is also $v \ll c$, so that the second order terms reduce each other. We still do not reduce the numerical coefficient c of the non-diagonal space-time terms so that they are easily recognized in the metric.

Because the non-holonomic metric (7) satisfies the most probable configuration for such a $(3+1)$-space, we regard it as the *background metric of the world*.

2.3 Study of the background metric. The main characteristics of the background space

We now calculate the main characteristics of the space which are invariant within a fixed three-dimensional spatial section, connected to an observer. Such quantities are related to the chronometric invariants, which are the physical observable quantities in General Relativity [15, 16, 17] (see Appendix 2).

After the components of the fundamental metric tensor $g_{\alpha\beta}$ are obtained from the background metric (7), we calculate the main observable characteristics of the space (see Appendix 2). It follows that in the space:

$$\frac{v}{c} = \frac{\bar{v}}{c} = \alpha = \text{const}, \qquad \frac{v\mathrm{v}}{c^2} = \frac{\alpha\bar{\mathrm{v}}}{c} = \frac{\bar{v}^2}{2\pi c^2} = \text{const}\,, \tag{9}$$

the gravitational potential w is zero

$$g_{00} = 1\,, \qquad \mathrm{w} = c^2\big(1-\sqrt{g_{00}}\big) = 0\,, \tag{10}$$

the linear velocity of the space rotation $v_i = -\frac{c\,g_{0i}}{\sqrt{g_{00}}}$ is

$$\left.\begin{aligned} v_1 &= -\bar{v}\,(\cos\varphi+\sin\varphi) \\ v_2 &= -\bar{v}r\,(\cos\varphi-\sin\varphi) \\ v_3 &= -\bar{v} \end{aligned}\right\} \tag{11}$$

the relativistic multiplier is unity (within the number of significant digits)

$$\frac{1}{\sqrt{1-\frac{\bar{\mathrm{v}}^2}{c^2}}} = \frac{1}{0.9999993} = 1\,, \tag{12}$$

the gravitational inertial force F_i, the angular velocity of the space rotation A_{ik}, the space deformation D_{ik}, and the space curvature C_{ik} are zero

$$F_i = 0\,, \quad A_{ik} = 0\,, \quad D_{ik} = 0\,, \quad C_{ik} = 0\,, \tag{13}$$

while of all the chr.inv.-Christoffel symbols Δ^i_{km}, only two components are non-zero,

$$\Delta^1_{22} = -r\,, \qquad \Delta^2_{12} = \frac{1}{r}\,. \tag{14}$$

The non-holonomic background space is free of distributed matter, so the energy-momentum tensor is zero therein. Hence, as seen from the chr.inv.-Einstein equations (see Appendix 2), the background space necessarily has

$$\lambda = 0\,, \tag{15}$$

i.e. it is also free of physical vacuum (λ-field). In other words, the non-holonomic background space is *empty*.

We conclude for the background space exposed by the non-holonomic background metric (7), that

> The non-holonomic background space satisfying the most probable configuration of the $(3+1)$-space of General Relativity is a flat pseudo-Riemannian space with the 3-dimensional Euclidean metric and a constant space-time rotation. The background space is empty; it permits neither distributed matter or vacuum (λ-field). The background space is not one an Einstein space (where $R_{\alpha\beta} = k\,g_{\alpha\beta}$, $k = \text{const}$) due to the fact that Einstein's equations have $k = 0$ in the background space. To be an Einstein space, the background space should be perturbed.

Read about Einstein spaces and their formal determination in *Einstein Spaces* by A. Z. Petrov [19].

It should be noted that of the fact that the 3-dimensional Euclidean metric means only $F_i = 0$, $A_{ik} = 0$, $D_{ik} = 0$ and $C_{ik} = 0$. The Christoffel symbols can be $\Delta^i_{mn} \neq 0$ due to the curvilinear coordinates.

$$ds^2 = \left(1 - \frac{2GM}{c^2 z}\right)c^2dt^2 + \frac{2v\,(\cos\varphi + \sin\varphi)}{c}\,cdt\,dr + \frac{2vr\,(\cos\varphi - \sin\varphi)}{c}\,cdt\,d\varphi + \frac{2v}{c}\,cdt\,dz - \\ - dr^2 + \frac{2v\mathrm{v}\,(\cos\varphi + \sin\varphi)}{c^2}\,dr\,dz - r^2 d\varphi^2 + \frac{2v\mathrm{v}r\,(\cos\varphi - \sin\varphi)}{c^2}\,d\varphi\,dz - \left(1 + \frac{2GM}{c^2 z}\right)dz^2 \qquad (20)$$

2.4 Perturbation of the non-holonomic background

How does a gravitational field and local rotation (the gravitational field of the Earth and the rotation of a disc, for instance) affect the metric? This we now describe.

The ratio v/c, according to the continuity condition in the space (see §2), equals Sommerfeld's fine-structure constant $\alpha = \bar{v}/c = 1/137.037498$ only if the non-holonomic background metric is *unperturbed* by a local rotation, so the space non-holonomity appears as a homogeneous field of the constant linear velocity of the space rotation $\bar{v}$, which is 2,187.671 km/sec. The gravitational potential w appears in General Relativity as $\mathrm{w} = c^2(1 - \sqrt{g_{00}})$, i.e. connected to g_{00}. So the presence of a gravity field changes the linear velocity of the space rotation $v_i = -\frac{c\,g_{0i}}{\sqrt{g_{00}}}$. For an Earth-bound laboratory, we have $\frac{\mathrm{w}}{c^2} = \frac{GM}{c^2 z} \simeq 7\times10^{-10}$. This numerical value is so small that perturbations of the non-holonomic background through g_{00}, by the Earth's gravitational field, are weak. Another case — local rotations. A local rotation with a linear velocity $\tilde{v}$ or a gravitational potential w perturbs the homogeneous field of the space non-holonomity, the ratio v/c in that area changes from the initial value $\alpha = \bar{v}/c = 1/137.037498$ to a new, perturbed value

$$\frac{v}{c} = \frac{\bar{v} + \tilde{v}}{c} = \alpha + \frac{\tilde{v}}{\bar{v}}\,\alpha\,. \qquad (16)$$

This fact should be taken into account in all formulae which include v or the derivatives.

Consider a high speed gyro used in aviation navigation: a 250 g rotor of 1.65″ diameter, rotating with an angular speed of 24,000 rpm. With modern equipment this is almost the uppermost speed for such a mechanically rotating system*. In such a case the background field of the space non-holonomity is perturbed near the giro as $\tilde{v} \approx 53$ m/sec, that is 2.4×10^{-5} of the background $\bar{v} = 2{,}187.671$ km/sec. Larger effects are expected for a submarine gyro, where the rotor and, hence, the linear velocity of the rotation is larger. In other words, the non-holonomic background can be substantially perturbed near such a mechanically rotating system.

2.5 The background metric perturbed by a gravitational field

The formula for the linear velocity of the space rotation

$$v_i = -c\,\frac{g_{0i}}{\sqrt{g_{00}}}\,, \qquad (17)$$

was derived by Zelmanov [15, 16, 17], due to the space non-holonomity, and originating in it. It is evident that if the same numerical value $v_i = \mathrm{const}$ remains unchanged everywhere in the spatial section (i.e. ${}^*\nabla_i\, v^i = 0$)†

$$\left.\begin{aligned} v_i &= \mathrm{const} \\ {}^*\nabla_i\, v^i &= 0 \end{aligned}\right\} \qquad (18)$$

there is a *homogeneous field of the space non-holonomity*. By the formula (17), given a homogeneous field of the space non-holonomity, any local rotation of the space (expressed with g_{0i}) and also a gravitational potential (contained in g_{00}) perturb the homogeneous non-holonomic background.

We modify the background metric (7) to that case where the homogeneous non-holonomic background is perturbed by a weak gravitational field, produced by a bulky point mass M, that is usual for observations in a laboratory located on the Earth's surface or near orbit. The gravitational potential in General Relativity is $\mathrm{w} = c^2(1 - \sqrt{g_{00}})$. We assume gravity acting in the z-direction, i.e. $\mathrm{w} = \frac{GM}{z}$, and we omit terms of higher than the second order in c, following the usual approximation in General Relativity (see Landau and Lifshitz [20] for instance). We substitute

$$g_{00} = \left(1 - \frac{\mathrm{w}}{c^2}\right)^2 = \left(1 - \frac{GM}{c^2 z}\right)^2 \simeq 1 - \frac{2GM}{c^2 z} \neq 1 \qquad (19)$$

into the first term of the initial metric (5). After Lorentz' transformations, we obtain a formula for the non-holonomic background metric (7) perturbed by such a field of gravity. This is formula (20) displayed on the top of this page.

2.6 The background metric perturbed by a local oscillation and gravitational field

A superconducting disc in air under the influence of an alternating magnetic field of an electromagnet located beneath it, undergoes oscillatory bounces with the frequency of the current, in a vertical direction (the same that of the Earth's gravity — the z-direction in our cylindrical coordinates).

We set up a harmonic transformation of the z-coordinate

$$\tilde{z} = z + z_0 \cos\frac{\Omega}{c}\,u\,, \qquad u = ct + z\,, \qquad (21)$$

where z_0 is the initial deviation (the amplitude of the oscillation), while Ω is the frequency. After calculating $d\tilde{z}$ and $d\tilde{z}^2$ (22), and using these instead of dz and dz^2 in the non-holonomic background metric (7), we obtain the background metric (7) perturbed by the local oscillation and gravitational field. This is formula (23) shown above.

*Mechanical gyros used in aviation and submarine navigation technology have rotations in the range 6,000–30,000 rpm. The upper speed is limited by problems due to friction.

†See Appendix 2 for the chr.inv.-differentiation symbol ${}^*\nabla$.

$$\left.\begin{aligned} d\tilde{z} &= \left(1-\frac{\Omega z_0}{c}\sin\frac{\Omega}{c}u\right)dz - \left(\frac{\Omega z_0}{c}\sin\frac{\Omega}{c}u\right)cdt \\ d\tilde{z}^2 &= \left(1-\frac{\Omega z_0}{c}\sin\frac{\Omega}{c}u\right)^2 dz^2 - \frac{2\Omega z_0}{c}\sin\frac{\Omega}{c}u\left(1-\frac{\Omega z_0}{c}\sin\frac{\Omega}{c}u\right)cdt\,dz + \left(\frac{\Omega^2 z_0^2}{c^2}\sin^2\frac{\Omega}{c}u\right)c^2dt^2 \end{aligned}\right\} \tag{22}$$

$$\begin{aligned} ds^2 &= \left[1-\frac{2GM}{c^2\left(z+z_0\cos\frac{\Omega}{c}u\right)} - \frac{2v\Omega z_0}{c^2}\sin\frac{\Omega}{c}u - \frac{\Omega^2 z_0^2}{c^2}\sin^2\frac{\Omega}{c}u\right]c^2dt^2 + \\ &+ \frac{2v\left(\cos\varphi+\sin\varphi\right)}{c}\left(1-\frac{\Omega z_0 \mathrm{v}}{c^2}\sin\frac{\Omega}{c}u\right)cdt\,dr + \frac{2vr\left(\cos\varphi-\sin\varphi\right)}{c}\left(1-\frac{\Omega z_0 \mathrm{v}}{c^2}\sin\frac{\Omega}{c}u\right)cdt\,d\varphi + \\ &+ \frac{2}{c}\left(1-\frac{\Omega z_0 \mathrm{v}}{c^2}\sin\frac{\Omega}{c}u\right)\left\{v+\Omega z_0\sin\frac{\Omega}{c}u\left[1+\frac{2GM}{c^2\left(z+z_0\cos\frac{\Omega}{c}u\right)}\right]\right\}cdt\,dz - dr^2 + \\ &+ \frac{2v\mathrm{v}\left(\cos\varphi+\sin\varphi\right)}{c^2}\left(1-\frac{\Omega z_0}{c^2}\sin\frac{\Omega}{c}u\right)dr\,dz - r^2d\varphi^2 + \frac{2v\mathrm{v}r\left(\cos\varphi-\sin\varphi\right)}{c^2}\left(1-\frac{\Omega z_0}{c}\sin\frac{\Omega}{c}u\right)d\varphi\,dz - \\ &- \left[1+\frac{2GM}{c^2\left(z+z_0\cos\frac{\Omega}{c}u\right)}\right]\left(1-\frac{\Omega z_0}{c}\sin\frac{\Omega}{c}u\right)^2 dz^2 \end{aligned} \tag{23}$$

$$\begin{aligned} ds^2 &= \left(1-\frac{2GM}{c^2 z} - \frac{2\Omega z_0 v}{c^2}\sin\frac{\Omega}{c}u\right)c^2dt^2 + \frac{2v\left(\cos\varphi+\sin\varphi\right)}{c}cdt\,dr + \frac{2vr\left(\cos\varphi-\sin\varphi\right)}{c}cdt\,d\varphi + \\ &+ \frac{2}{c}\left(v+\Omega z_0\sin\frac{\Omega}{c}u\right)cdt\,dz - dr^2 - r^2d\varphi^2 - dz^2 \end{aligned} \tag{25}$$

3 The space of a suspended, vertically oscillating disc

3.1 The main characteristics of the space

Metric (23) is very difficult in use. However, under the physical conditions of a real experiment, many terms vanish so that the metric reduces to a simple form. We show how.

Consider a system like that used by Podkletnov in his experiment: a horizontally oriented disc suspended in air due to an alternating high-frequent magnetic field generated by an electromagnet located beneath the disc. Such a disc undergoes an oscillatory bounce along the vertical axis with a frequency which is the same as that of the alternating magnetic field. We apply metric (23) to this case, i.e. the metric of the space near such a disc.

First, because the initial deviation of such a disc from the rest point is very small ($z_0 \ll z$), we have

$$\frac{2GM}{c^2\left(z+z_0\cos\frac{\Omega}{c}u\right)} \simeq \frac{2GM}{c^2 z}\left(1-\frac{z_0}{z}\cos\frac{\Omega}{c}u\right) \simeq \frac{2GM}{c^2 z}\,. \tag{24}$$

Second, the relativistic square is $K=1$. Third, under the conditions of a real experiment like Podkletnov's, the terms $\frac{\Omega^2 z_0^2}{c^2}$ $\frac{\Omega^2 z_0}{c}$, $\frac{\Omega z_0}{c}$, $\frac{v^2}{c^2}$ and $\frac{v}{c}$ have such small numerical values that they can be omitted from the equations. The metric (23) then takes the much simplified form, shown as expression (25) at the top of this page. In other words, the expression (25) represents the metric of the space of a disc which undergoes an oscillatory bounce orthogonal to its own plane, in the conditions of a real experiment. This is the *main metric* which will be used henceforth in our study for the Podkletnov effect.

We calculate the main observable characteristics of such a space according to Appendix 2.

In such a space the gravitational potential w and the components of the linear velocity of the space rotation v_i are

$$\mathrm{w} = \frac{GM}{z} + \left(\Omega z_0\sin\frac{\Omega}{c}u\right)v\,, \tag{26}$$

$$\left.\begin{aligned} v_1 &= -v\left(\cos\varphi+\sin\varphi\right) \\ v_2 &= -vr\left(\cos\varphi-\sin\varphi\right) \\ v_3 &= -v-\Omega z_0\sin\frac{\Omega}{c}u \end{aligned}\right\}. \tag{27}$$

The components of the gravitational inertial force F_i acting in such a space are

$$\left.\begin{aligned} F_1 &= \left(\Omega z_0\sin\frac{\Omega}{c}u\right)v_r + \left(\cos\varphi+\sin\varphi\right)v_t \\ F_2 &= \left(\Omega z_0\sin\frac{\Omega}{c}u\right)v_\varphi + r\left(\cos\varphi-\sin\varphi\right)v_t \\ F_3 &= \left(\Omega z_0\sin\frac{\Omega}{c}u\right)v_z - \frac{GM}{z^2} + v_t + \\ &\quad + \Omega^2 z_0\cos\frac{\Omega}{c}u \end{aligned}\right\}, \tag{28}$$

where the quantities v_r, v_φ, v_z, v_t denote the respective partial derivatives of v.

In such a space the components of the tensor of the angular velocities of the space rotation A_{ik} are

$$\left.\begin{aligned} A_{12} &= \frac{1}{2}\left(\cos\varphi+\sin\varphi\right)v_{\varphi}-\frac{r}{2}\left(\cos\varphi-\sin\varphi\right)v_{r} \\ A_{23} &= \frac{r}{2}\left(\cos\varphi-\sin\varphi\right)v_{z}-\frac{1}{2}\,v_{\varphi} \\ A_{13} &= \frac{1}{2}\left(\cos\varphi+\sin\varphi\right)v_{z}-\frac{1}{2}\,v_{r} \end{aligned}\right\}. \qquad (29)$$

Because we omit all quantities proportional to $\frac{v^2}{c^2}$, the chr.inv.-metric tensor $h_{ik}=-g_{ik}+\frac{1}{c^2}v_i v_k$ (the observable 3-dimensional metric tensor) becomes $h_{ik}=-g_{ik}$. Its components for the metric (25) are

$$\left.\begin{aligned} & h_{11}=1\,, \quad h_{22}=r^2, \quad h_{33}=1 \\ & h^{11}=1\,, \quad h^{22}=\frac{1}{r^2}\,, \quad h^{33}=1 \\ & h=\det\|h_{ik}\|=r^2, \qquad \frac{\partial \ln\sqrt{h}}{\partial x^1}=\frac{1}{r} \end{aligned}\right\}. \qquad (30)$$

For the tensor of the space deformation D_{ik} we obtain

$$D_{33}=D^{33}=0\,, \qquad D=h^{ik}D_{ik}=0\,. \qquad (31)$$

Among the chr.inv.-Christoffel symbols Δ^i_{km} within the framework of our approximation, only two components are non-zero,

$$\Delta^1_{22}=-r\,, \qquad \Delta^2_{12}=\frac{1}{r}\,, \qquad (32)$$

so, despite the fact that the observable curvature tensor C_{ik} which possesses all the properties of Ricci's tensor $R_{\alpha\beta}$ on the 3-dimensional spatial section (see Appendix 2) isn't zero in the space, but within the framework of our assumption it is meant to be zero: $C_{ik}=0$. In other words, although the space curvature isn't zero, it is so small that it is negligible in a real experiment such as we are considering.

These are the physical observable characteristics of a space volume element located in an Earth-bound laboratory, where the non-holonomic background of the space is perturbed by a disc which undergoes oscillatory bounces orthogonal to its own plane.

We have now obtained all the physical observable characteristics of space required by Einstein's equations. Einstein's equations describe flows of energy, momentum and matter. Using the derived equations, we will know in precisely those flows of energy and momentum near a disc which undergoes an oscillatory bounce orthogonal to its own plane. So if there is any additional energy flow or momentum flow generated by the disc, Einstein's equations show this.

3.2 Einstein's equations in the space. First conclusion about the origin of the Podkletnov effect

Einstein's equations, in terms of the physical observable quantities given in Appendix 2, were derived in the 1940's by Zelmanov [15, 16, 17] as the projections of the general covariant (4-dimensional) Einstein equations

$$R_{\alpha\beta}-\frac{1}{2}\,g_{\alpha\beta}R=-\kappa\,T_{\alpha\beta}+\lambda\,g_{\alpha\beta} \qquad (33)$$

onto the time line and spatial section of an observer.

We omit the λ-term due to its negligible effect. In considering a real situation like Podkletnov's experiment, we assume the same approximation as in the previous Section. We also take into account those physical observable characteristics of the space which are zero according to our calculation.

Einstein's equations expressed in the terms of the physical observable quantities (see Appendix 2 for the complete equations) then take the following simplified form

$$\left.\begin{aligned} & \frac{\partial F^i}{\partial x^i}-A_{ik}A^{ik}+\frac{\partial \ln\sqrt{h}}{\partial x^i}\,F^i=-\frac{\kappa}{2}\left(\rho c^2+U\right) \\ & \frac{\partial A^{ij}}{\partial x^j}+\frac{\partial \ln\sqrt{h}}{\partial x^j}\,A^{ij}=-\kappa J^i \\ & 2A_{ij}A^{\cdot j}_{k\cdot}+\frac{1}{2}\left(\frac{\partial F_i}{\partial x^k}+\frac{\partial F_k}{\partial x^i}-2\Delta^m_{ik}F_m\right)= \\ & \qquad =\frac{\kappa}{2}\left(\rho c^2-U\right)h_{ik}+\kappa U_{ik} \end{aligned}\right\} \qquad (34)$$

where $\rho=\frac{T_{00}}{g_{00}}$, $J^i=\frac{cT^i_0}{\sqrt{g_{00}}}$ and $U^{ik}=c^2T^{ik}$ are the observable projections of the energy-momentum tensor $T_{\alpha\beta}$ of distributed matter on the right side of Einstein's equations (the right side determines distributed matter which fill the space, while the left side determines the geometrical properties of the space). By their physical sense, ρ is the observable density of the energy of the matter field, J^i is the observable density of the field momentum, U^{ik} is the observable stress-tensor of the field.

In relation to Podkletnov's experiment, $T_{\alpha\beta}$ is the sum of the energy-momentum tensor of an electromagnetic field, generated by an electromagnet located beneath the disc, and also that of the other fields filling the space. We therefore attribute the energy-momentum tensor $T_{\alpha\beta}$ and its observable components ρ, J^i, U^{ik} to the common field.

Is there additional energy and momentum produced by the field of the background space non-holonomity in order to compensate for a perturbation therein, due to a disc undergoing oscillatory bounces orthogonal to its own pane? This is easy to answer using Einstein's equations, owing to the fact that given the unperturbed field of the background space non-holonomity, the linear velocity of the space rotation v isn't a function of the spatial coordinates and time $v\neq f(r,\varphi,z,t)$. After F_i, A_{ik}, D_{ik}, and Δ^i_{kn} specific to the space of a suspended, vertically oscillating disc are substituted into Einstein's equations (34), the left side of the equations should contain additional terms dependent on the derivatives of v by the spatial coordinates r, φ, z, and time t. The additional terms, appearing in the left side, build

$$\left.\begin{aligned}
&(\cos\varphi+\sin\varphi)\,v_{tr}+(\cos\varphi-\sin\varphi)\,\frac{v_{t\varphi}}{r}+v_{tz}-(1-\cos\varphi\sin\varphi)\,v_r^2-v_z^2-\\
&-(1+\cos\varphi\sin\varphi)\,\frac{v_\varphi^2}{r^2}+\left(\cos^2\!\varphi-\sin^2\!\varphi\right)\frac{v_r v_\varphi}{r}+(\cos\varphi+\sin\varphi)\,v_r v_z+\\
&+(\cos\varphi-\sin\varphi)\,\frac{v_\varphi v_z}{r}+\frac{2GM}{z^3}+\left(\Omega z_0\sin\frac{\Omega}{c}u\right)\left(v_{rr}+\frac{v_{\varphi\varphi}}{r^2}+v_{zz}+\frac{v_r}{r}\right)=-\frac{\kappa}{2}\left(\rho c^2+U\right)\\
&\frac{(\cos\varphi-\sin\varphi)}{2r}\left(v_{r\varphi}-\frac{v_\varphi}{r}\right)-\frac{(\cos\varphi+\sin\varphi)}{2}\left(\frac{v_{\varphi\varphi}}{r^2}+v_{zz}+\frac{v_r}{r}\right)+\frac{1}{2}\,v_{rz}=\kappa J^1\\
&\frac{1}{2r^2}\left[v_{\varphi z}+(\cos\varphi+\sin\varphi)\left(v_{r\varphi}-\frac{v_\varphi}{r}\right)-r\,(\cos\varphi-\sin\varphi)\,(v_{rr}+v_{zz})\right]=\kappa J^2\\
&\frac{(\cos\varphi+\sin\varphi)}{2}\,v_{rz}+\frac{(\cos\varphi-\sin\varphi)}{2}\frac{v_{\varphi z}}{r}-\frac{1}{2}\left(v_{rr}+\frac{v_{\varphi\varphi}}{r^2}+\frac{v_r}{r}\right)=\kappa J^3\\
&(1-\cos\varphi\sin\varphi)\,v_r^2-\left(\cos^2\!\varphi-\sin^2\!\varphi\right)\frac{v_r v_\varphi}{r}+\frac{(1+2\cos\varphi\sin\varphi)}{2}\left(\frac{v_\varphi^2}{r^2}+v_z^2\right)+\\
&+\,(\cos\varphi+\sin\varphi)\,v_{tr}-(\cos\varphi+\sin\varphi)\,v_r v_z+\left(\Omega z_0\sin\frac{\Omega}{c}u\right)v_{rr}=\frac{\kappa}{2}\left(\rho c^2-U\right)+\kappa U_{11}\\
&\frac{1}{2}\Bigg[r\left(\cos^2\!\varphi-\sin^2\!\varphi\right)v_z^2+v_r v_\varphi-r\,(\cos\varphi-\sin\varphi)\,v_r v_z-(\cos\varphi+\sin\varphi)\,v_\varphi v_z+\\
&+(\cos\varphi+\sin\varphi)\,v_{t\varphi}+r\,(\cos\varphi-\sin\varphi)\,v_{tr}+2\left(\Omega z_0\sin\frac{\Omega}{c}u\right)\left(v_{r\varphi}-\frac{v_\varphi}{r}\right)\Bigg]=\kappa U_{12}\\
&\frac{1}{2}\Bigg[v_{tr}+(\cos\varphi+\sin\varphi)\,v_{tz}-(\cos\varphi-\sin\varphi)\,\frac{v_r v_\varphi}{r}+(1-2\cos\varphi\sin\varphi)\,v_r v_z+\\
&+(\cos\varphi+\sin\varphi)\,\frac{v_\varphi^2}{r^2}-\left(\cos^2\!\varphi-\sin^2\!\varphi\right)\frac{v_\varphi v_z}{r}+2\left(\Omega z_0\sin\frac{\Omega}{c}u\right)v_{rz}\Bigg]=\kappa U_{13}\\
&\frac{(1-2\cos\varphi\sin\varphi)}{2}\left(v_r^2+v_z^2\right)-\left(\cos^2\!\varphi-\sin^2\!\varphi\right)\frac{v_r v_\varphi}{r}+(1+\cos\varphi\sin\varphi)\,\frac{v_\varphi^2}{r^2}+\\
&+(\cos\varphi-\sin\varphi)\,\frac{v_{t\varphi}}{r}-(\cos\varphi-\sin\varphi)\,\frac{v_\varphi v_z}{r}+\left(\Omega z_0\sin\frac{\Omega}{c}u\right)\left(\frac{v_{\varphi\varphi}}{r^2}+\frac{v_r}{r}\right)=\frac{\kappa}{2}\left(\rho c^2-U\right)+\frac{\kappa U_{22}}{r^2}\\
&\frac{1}{2}\Bigg[v_{t\varphi}+r\,(\cos\varphi-\sin\varphi)\,v_{tz}+r\,(\cos\varphi-\sin\varphi)\,v_r^2-(\cos\varphi+\sin\varphi)\,v_r v_\varphi-\\
&-\,r\left(\cos^2\!\varphi-\sin^2\!\varphi\right)v_r v_z+(1+2\cos\varphi\sin\varphi)\,v_\varphi v_z+2\left(\Omega z_0\sin\frac{\Omega}{c}u\right)v_{\varphi z}\Bigg]=\kappa U_{23}\\
&\frac{v_r^2}{2}+v_z^2-(\cos\varphi+\sin\varphi)\,v_r v_z+\frac{v_\varphi^2}{2r^2}-(\cos\varphi-\sin\varphi)\,\frac{v_\varphi v_z}{r}+v_{tz}+\frac{2GM}{z^3}+\\
&+\left(\Omega z_0\sin\frac{\Omega}{c}u\right)v_{zz}=\frac{\kappa}{2}\left(\rho c^2-U\right)+\kappa U_{33}
\end{aligned}\right\}\qquad(35)$$

respective additions to the energy and momentum of the acting electromagnetic field on the right side of the equations.

Following this line, we are looking for the energy and momentum produced by the field of the background space non-holonomity due to perturbation therein.

We substitute F_i (28), A_{ik} (29), D_{ik} (31), and Δ^i_{kn} (32), specific to the space of such an oscillating disc, into the chr.inv.-Einstein equations (34), and obtain the Einstein equations as shown in formula (35). These are actually Einstein's equations for the initial homogeneous non-holonomic space perturbed by such a disc.

As seen from the left side of the Einstein equations (35), a new energy-momentum field appears near the disc due to the appearance of a non-uniformity of the field of the background space non-holonomity (i.e. due to the functions v of the coordinates and time):

1. The field bears additional energy to the electromagnetic field energy represented in the space (see the scalar Einstein equation);
2. The field has momentum flow J^i. The momentum flow spreads from the outer space toward the disc in the r-direction, twists around the disc in the φ-direction, then rises above the disc in the z-direction (see the vectorial Einstein equations which describe the momentum flow J^1, J^2, and J^3 toward r, φ, and z-direction respectively). This purely theoretical finding explains the Podkletnov effect. According to Eugene Podkletnov, a member of his experimental team smoked a pipe a few meters away from the cryostat with the superconducting disc, during operation. By a stroke of luck, Podkletnov noticed that the tobacco smoke was attracted towards the cryostat, then twisted around it and rose above it. Podkletnov then applied a high precision balance, which immediately showed a weight loss over the cryostat. Now it is clear that the tobaccosmoke revealed the momentum flow produced by the background space non-holonomity field perturbed near the vertically oscillating disc;
3. The field has distributed stresses which are expressed by an addition to the electromagnetic field stress-tensor (see the Einstein tensor equations).

In the simplest case where Podkletnov's experiment is run in a completely holonomic space ($v=0$) the Einstein equations (35) take the simplest form

$$\left.\begin{aligned} &\frac{2GM}{z^3} = -\kappa\rho c^2 \\ &J^1 = 0\,,\quad J^2 = 0\,,\quad J^3 = 0 \\ &U_{11} = 0\,,\ U_{12} = 0\,,\ U_{13} = 0\,,\ U_{22} = 0\,,\ U_{23} = 0 \\ &\frac{2GM}{z^3} = \kappa U_{33} \end{aligned}\right\} \quad (36)$$

This is also true in another case, where the space is non-holonomic ($v \neq 0$) but v isn't function of the spatial coordinates and time $v \neq f(r, \varphi, z, t)$, that is the unperturbed homogeneous field of the background space non-holonomity. We see that in both cases there is no additional energy and momentum flow near the disc; only the electromagnetic field flow is put into equilibrium by the Earth's gravity, directed vertically along the z-axis.

So Einstein's equations show clearly that:

> The Podkletnov effect is due to the fact that the field of the background space non-holonomity, being perturbed by a suspended, vertically oscillating disc, produces energy and momentum flow in order to compensate for the perturbation therein.

3.3 Complete geometrization of matter

Looking at the right side of the Einstein equations (35), which determine distributed matter, we see that ρ and U are included only in the scalar (first) equation and also three tensor equations with the indices 11, 22, 33 (the 5th, 8th, and 10th equations). We can therefore find a formula for U. Then, substituting the formula back into the Einstein equations for ρ and U_{11}, U_{22}, U_{33}, we can express the characteristics of distributed matter through only the physical observable characteristics of the space. This fact, coupled with the fact that the other characteristics of distributed matter (J^1, J^2, J^3, U_{12}, U_{13}, U_{13}) are expressed through only the physical observable characteristics of the space by the 2nd, 3rd, 4th, 6th, 7th, and 9th equations of the Einstein equations (35), means that considering a space in which the homogeneous non-holonomic background is perturbed by an oscillating disc, we can obtain a *complete geometrization of matter*.

Multiplying the 1st equation of (35) by the 3rd, then summing with the 5th, 8th, and 10th equations, we eliminate ρ. Then, because $U = h^{ik}U_{ik} = U_{11} + \frac{U_{22}}{r^2} + U_{33}$, we obtain a formula for U expressed only via the physical observable characteristics of the space. Substituting the obtained formula for κU into the 1st equation, we obtain a formula for ρ. After that it is easy to obtain $\rho c^2 + U$ and $\rho c^2 - U$. Using these in the three Einstein tensor equations with the diagonal indices 11, 22, 33, we obtain formulae for U_{11}, U_{22}, U_{33}, all expressed only in terms of the physical observable characteristics of the space.

The resulting equations, coupled with those of the Einstein equations (35) which determine J^1, J^2, J^3, U_{12}, U_{13}, and U_{13}, build the system of the equations (37), which completely determine the properties of distributed matter — the density of the energy ρ, the density of the momentum flow J^I, and the stress-tensor U_{ik} — only in terms of the physical observable characteristics of the space. So:

> Matter which fills the space, where a homogeneous non-holonomic background is perturbed by an oscillating disc *is completely geometrized*.

$$\left.\begin{aligned}
&\kappa U = \frac{(1-\cos\varphi\sin\varphi)}{2}\,v_r^2 + \frac{(1+\cos\varphi\sin\varphi)}{2}\frac{v_\varphi^2}{r^2} + \frac{v_z^2}{2} - \frac{\left(\cos^2\varphi-\sin^2\varphi\right)}{2}\frac{v_r v_\varphi}{r} - \\
&- \frac{(\cos\varphi-\sin\varphi)}{2}\frac{v_\varphi v_z}{r} - \frac{(\cos\varphi+\sin\varphi)}{2}\,v_r v_z - 2\left(\cos\varphi+\sin\varphi\right) v_{tr} - \\
&- 2\left(\cos\varphi-\sin\varphi\right)\frac{v_{t\varphi}}{r} - 2\,v_{tz} - \frac{4GM}{z^3} - 2\left(\Omega z_0\sin\frac{\Omega}{c}u\right)\left(v_{rr}+\frac{v_{\varphi\varphi}}{r^2}+v_{zz}+\frac{v_r}{r}\right) \\
&\kappa\rho c^2 = \frac{3}{2}\Big[(1-\cos\varphi\sin\varphi)\,v_r^2 + (1+\cos\varphi\sin\varphi)\frac{v_\varphi^2}{r^2} + v_z^2 - \\
&- \left(\cos^2\varphi-\sin^2\varphi\right)\frac{v_r v_\varphi}{r} - (\cos\varphi-\sin\varphi)\frac{v_\varphi v_z}{r} - (\cos\varphi+\sin\varphi)\,v_r v_z\Big] \\
&\frac{\kappa}{2}\left(\rho c^2-U\right) = \frac{(1-\cos\varphi\sin\varphi)}{2}\,v_r^2 + \frac{(1+\cos\varphi\sin\varphi)}{2}\frac{v_\varphi^2}{r^2} + \frac{v_z^2}{2} - \frac{\left(\cos^2\varphi-\sin^2\varphi\right)}{2}\frac{v_r v_\varphi}{r} - \\
&- \frac{(\cos\varphi-\sin\varphi)}{2}\frac{v_\varphi v_z}{r} - \frac{(\cos\varphi+\sin\varphi)}{2}\,v_r v_z + (\cos\varphi+\sin\varphi)\,v_{tr} + (\cos\varphi-\sin\varphi)\frac{v_{t\varphi}}{r} + \\
&+ v_{tz} + \frac{2GM}{z^3} + \left(\Omega z_0\sin\frac{\Omega}{c}u\right)\left(v_{rr}+\frac{v_{\varphi\varphi}}{r^2}+v_{zz}+\frac{v_r}{r}\right) \\
&\kappa J^1 = \frac{(\cos\varphi-\sin\varphi)}{2r}\left(v_{r\varphi}-\frac{v_\varphi}{r}\right) - \frac{(\cos\varphi+\sin\varphi)}{2}\left(\frac{v_{\varphi\varphi}}{r^2}+v_{zz}+\frac{v_r}{r}\right) + \frac{1}{2}\,v_{rz} \\
&\kappa J^2 = \frac{1}{2r^2}\left[v_{\varphi z} + (\cos\varphi+\sin\varphi)\left(v_{r\varphi}-\frac{v_\varphi}{r}\right) - r\,(\cos\varphi-\sin\varphi)\,(v_{rr}+v_{zz})\right] \\
&\kappa J^3 = \frac{(\cos\varphi+\sin\varphi)}{2}\,v_{rz} + \frac{(\cos\varphi-\sin\varphi)}{2}\frac{v_{\varphi z}}{r} - \frac{1}{2}\left(v_{rr}+\frac{v_{\varphi\varphi}}{r^2}+\frac{v_r}{r}\right) \\
&\kappa U_{11} = \frac{(1-\cos\varphi\sin\varphi)}{2}\,v_r^2 + (\cos\varphi\sin\varphi)\left(\frac{v_\varphi^2}{2r^2}+v_z^2\right) - \frac{\left(\cos^2\varphi-\sin^2\varphi\right)}{2}\frac{v_r v_\varphi}{r} - \frac{(\cos\varphi+\sin\varphi)}{2}\,v_r v_z + \\
&+ \frac{(\cos\varphi-\sin\varphi)}{2}\frac{v_\varphi v_z}{r} - (\cos\varphi-\sin\varphi)\frac{v_{t\varphi}}{r} - v_{tz} - \frac{2GM}{z^3} - \left(\Omega z_0\sin\frac{\Omega}{c}u\right)\left(\frac{v_{\varphi\varphi}}{r^2}+v_{zz}+\frac{v_r}{r}\right) \\
&\kappa U_{12} = \frac{1}{2}\Big[r\left(\cos^2\varphi-\sin^2\varphi\right)v_z^2 + v_r v_\varphi - r\,(\cos\varphi-\sin\varphi)\,v_r v_z - (\cos\varphi+\sin\varphi)\,v_\varphi v_z + \\
&+ (\cos\varphi+\sin\varphi)\,v_{t\varphi} + r\,(\cos\varphi-\sin\varphi)\,v_{tr} + 2\left(\Omega z_0\sin\frac{\Omega}{c}u\right)\left(v_{r\varphi}-\frac{v_\varphi}{r}\right)\Big] \\
&\kappa U_{13} = \frac{1}{2}\Big[v_{tr} + (\cos\varphi+\sin\varphi)\,v_{tz} - (\cos\varphi-\sin\varphi)\frac{v_r v_\varphi}{r} + (1-2\cos\varphi\sin\varphi)\,v_r v_z + \\
&+ (\cos\varphi+\sin\varphi)\frac{v_\varphi^2}{r^2} - \left(\cos^2\varphi-\sin^2\varphi\right)\frac{v_\varphi v_z}{r} + 2\left(\Omega z_0\sin\frac{\Omega}{c}u\right)v_{rz}\Big] \\
&\frac{\kappa U_{22}}{r^2} = -(\cos\varphi\sin\varphi)\left(\frac{v_r^2}{2}+v_z^2\right) + \frac{(1+\cos\varphi\sin\varphi)}{2}\frac{v_\varphi^2}{r^2} - \frac{\left(\cos^2\varphi-\sin^2\varphi\right)}{2}\frac{v_r v_\varphi}{r} - \\
&- \frac{(\cos\varphi-\sin\varphi)}{2}\frac{v_\varphi v_z}{r} + \frac{(\cos\varphi+\sin\varphi)}{2}\,v_r v_z - (\cos\varphi+\sin\varphi)\,v_{tr} - v_{tz} - \frac{2GM}{z^3} - \left(\Omega z_0\sin\frac{\Omega}{c}u\right)(v_{rr}+v_{zz}) \\
&\kappa U_{23} = \frac{1}{2}\Big[v_{t\varphi} + r\,(\cos\varphi-\sin\varphi)\,v_{tz} + r\,(\cos\varphi-\sin\varphi)\,v_r^2 - (\cos\varphi+\sin\varphi)\,v_r v_\varphi - \\
&- r\left(\cos^2\varphi-\sin^2\varphi\right)v_r v_z + (1+2\cos\varphi\sin\varphi)\,v_\varphi v_z + 2\left(\Omega z_0\sin\frac{\Omega}{c}u\right)v_{\varphi z}\Big] \\
&\kappa U_{33} = \frac{(\cos\varphi\sin\varphi)}{2}\left(v_r^2-\frac{v_\varphi^2}{r^2}\right) + \frac{v_z^2}{2} - \frac{(\cos\varphi+\sin\varphi)}{2}\,v_r v_z + \frac{\left(\cos^2\varphi-\sin^2\varphi\right)}{2}\frac{v_r v_\varphi}{r} - \\
&- \frac{(\cos\varphi-\sin\varphi)}{2}\frac{v_\varphi v_z}{r} - (\cos\varphi+\sin\varphi)\,v_{tr} - (\cos\varphi-\sin\varphi)\frac{v_{t\varphi}}{r} - \left(\Omega z_0\sin\frac{\Omega}{c}u\right)\left(v_{rr}+\frac{v_{\varphi\varphi}}{r^2}+\frac{v_r}{r}\right)
\end{aligned}\right\}\qquad(37)$$

There is just one question still to be answered. What is the nature of the matter?

Among the matter different from the gravitational field, only the isotropic electromagnetic field was previously geometrized — that for which the metric is determined by the Rainich condition [23, 24, 25]

$$R = 0\,, \qquad R_{\alpha\rho}R^{\rho\beta} = \frac{1}{4}\,\delta^{\beta}_{\alpha}\left(R_{\rho\sigma}R^{\rho\sigma}\right) = 0 \qquad (38)$$

and the Nordtvedt-Pagels condition [26]

$$\eta_{\mu\varepsilon\gamma\sigma}\left(R^{\delta\gamma;\sigma}R^{\varepsilon\tau} - R^{\delta\varepsilon;\sigma}R^{\gamma\tau}\right) = 0\,. \qquad (39)$$

The Rainich condition and the Nordtvedt-Pagels condition, being applied to the left side of Einstein's equations, completely determine the properties of the isotropic electromagnetic field on the right side. In other words, the aforementioned conditions determine both the geometric properties of the space and the properties of a pervading isotropic electromagnetic field.

An isotropic electromagnetic field is such where the field invariants $F_{\alpha\beta}F^{\alpha\beta}$ and $F_{*\alpha\beta}F^{\alpha\beta}$, constructed from the electromagnetic field tensor $F_{\alpha\beta}$ and the field pseudo-tensor $F^{*\alpha\beta} = \frac{1}{2}\,\eta^{\alpha\beta\mu\nu}F_{\mu\nu}$ dual, are zero

$$F_{\alpha\beta}F^{\alpha\beta} = 0\,, \qquad F_{*\alpha\beta}F^{\alpha\beta} = 0\,, \qquad (40)$$

so the isotropic electromagnetic field has a structure truncated to that of an electromagnetic field in general.

In our case we have no limitation on the structure of the electromagnetic field, so we use the energy-momentum tensor of the electromagnetic field in the general form [20]

$$T_{\alpha\beta} = \frac{1}{4\pi}\left(-F_{\alpha\sigma}F_{\beta\cdot}^{\cdot\sigma} + \frac{1}{4}\,F_{\mu\nu}F^{\mu\nu}g_{\alpha\beta}\right), \qquad (41)$$

whence the observable density of the field energy $\rho = \frac{T_{00}}{g_{00}}$ and the trace $U = h^{ik}U_{ik}$ of the observable stress-tensor of the field $U^{ik} = c^2T^{ik}$ are connected by the relation

$$\rho c^2 = U\,. \qquad (42)$$

In other words, if besides the gravitational field there is be only an electromagnetic field, we should have $\rho c^2 = U$ for distributed matter in the Einstein equations.

However, as seen in the 2nd equation of the system (37), $\rho c^2 - U \neq 0$ in the Einstein equations, for the only reason that, in the case we are considering, the laboratory space is filled not only by the Earth's gravitational field and an alternating magnetic field which supports the disc in air, but also another field appeared due to the fact that the oscillating disc perturbs the non-holonomic background of the space. The perturbation field, as shown in the previous Section, bears energy and momentum*, so it can be taken as a field of distributed matter. In other words,

> We have obtained a complete geometrization of matter consisting of an arbitrary electromagnetic field and a perturbation field of the non-holonomic background of the space.

*The fact that the space non-holonomity field bears energy and momentum was first shown in the earlier publication [27], where the field of a reference body was considered.

3.4 The conservation law

When considering the geodesic equations in a space, the hon-holonomic background of which is perturbed by a disc undergoing oscillatory bounces orthogonal to its own plane, we need to know the space distribution of the perturbation, i.e. some relations between the functions $v_t = \frac{\partial v}{\partial t}$, $v_r = \frac{\partial v}{\partial r}$, $v_\varphi = \frac{\partial v}{\partial \varphi}$, $v_z = \frac{\partial v}{\partial z}$, which are respective partial derivatives of the value v of the linear velocity of the space rotation v_i.

The functions v_t, v_r, v_φ, v_z are contained in the left side (geometry) of the Einstein equations we have obtained. Therefore, from a formal point of view, to find the functions we should integrate the Einstein equations. However the Einstein equations are represented in a non-empty space, so the right side of the equations is not zero, but occupied by the energy-momentum tensor $T_{\alpha\beta}$ of distributed matter which fill the space. Hence, to obtain the functions v_t, v_r, v_φ, v_z from the Einstein equations, we should express the right side of the equations — the energy-momentum tensor of distributed matter $T_{\alpha\beta}$ — through the functions as well.

Besides, in our case, $T_{\alpha\beta}$ represents not only the energy-momentum of the electromagnetic field but also the energy-momentum produced by the field of the background space non-holonomity compensating the perturbation therein. Yet we cannot divide one energy-momentum tensor by another. So we must consider the energy-momentum tensor for the common field, which presents a problem, because we have no formulae for the components of the energy-momentum tensor of the common field. In other words, we are enforced to operate with the components of $T_{\alpha\beta}$ as merely some quantities ρ, J^i, and U^{ik}.

How to express $T_{\alpha\beta}$ through the functions v_t, v_r, v_φ, v_z, aside for by the Einstein equations? In another case we would be led to a dead end. However, our case of distributed matter is completely geometrized. In other words, the geometrical structure of the space and the space distribution of the energy-momentum tensor $T_{\alpha\beta}$ are the same things. We can therefore find the functions v_t, v_r, v_φ, v_z from the space distribution of $T_{\alpha\beta}$, via the equations of the conservation law

$$\nabla_\sigma T^{\alpha\sigma} = 0\,. \qquad (43)$$

The conservation law in the chr.inv.-form, i.e. represented as the projections of equation (43) onto the time line and spatial section of an observer, is [15]

$$\left.\begin{aligned} &\frac{^*\partial\rho}{\partial t} + D\rho + \frac{1}{c^2}D_{ij}U^{ij} + \left(^*\nabla_i - \frac{1}{c^2}F_i\right)J^i - \frac{1}{c^2}F_iJ^i = 0 \\ &\frac{^*\partial J^k}{\partial t} + 2\left(D^k_i + A^{\cdot k}_{i\cdot}\right)J^i + \left(^*\nabla_i - \frac{1}{c^2}F_i\right)U^{ik} - \rho F^k = 0 \end{aligned}\right\} \qquad (44)$$

$$\left.\begin{aligned}
&\frac{\partial\rho}{\partial t}+\frac{\partial J^1}{\partial r}+\frac{\partial J^2}{\partial\varphi}+\frac{\partial J^3}{\partial z}+\frac{1}{r}\,J^1=0\\
&\frac{\partial J^1}{\partial t}-\big[(\cos\varphi+\sin\varphi)\,v_\varphi-r\,(\cos\varphi-\sin\varphi)\,v_r\big]\,J^2-\big[(\cos\varphi+\sin\varphi)\,v_z-v_r\big]\,J^3+\\
&+\frac{\partial U_{11}}{\partial r}+\frac{1}{r^2}\frac{\partial U_{12}}{\partial\varphi}+\frac{\partial U_{13}}{\partial z}+\frac{1}{r}\left(U_{11}-\frac{U_{22}}{r^2}\right)-\rho\left[\left(\Omega z_0\sin\frac{\Omega}{c}\,u\right)v_r+(\cos\varphi+\sin\varphi)\,v_t\right]=0\\
&\frac{\partial J^2}{\partial t}-\left[(\cos\varphi+\sin\varphi)\,\frac{v_\varphi}{r^2}-(\cos\varphi-\sin\varphi)\,\frac{v_r}{r}\right]J^1-\left[(\cos\varphi-\sin\varphi)\,\frac{v_z}{r}-\frac{v_\varphi}{r^2}\right]J^3+\\
&+\frac{\partial}{\partial r}\left(\frac{U_{12}}{r^2}\right)+\frac{1}{r^2}\left(\frac{1}{r^2}\frac{\partial U_{22}}{\partial\varphi}+\frac{\partial U_{23}}{\partial z}+\frac{3}{r}\,U_{12}\right)-\rho\left[\left(\Omega z_0\sin\frac{\Omega}{c}\,u\right)\frac{v_\varphi}{r^2}+\frac{(\cos\varphi-\sin\varphi)}{r}\,v_t\right]=0\\
&\frac{\partial J^3}{\partial t}+\big[(\cos\varphi+\sin\varphi)\,v_z-v_r\big]\,J^1+\big[r\,(\cos\varphi-\sin\varphi)\,v_z-v_\varphi\big]\,J^2+\\
&+\frac{\partial U_{13}}{\partial r}+\frac{1}{r^2}\frac{\partial U_{23}}{\partial\varphi}+\frac{\partial U_{33}}{\partial z}+\frac{1}{r}\,U_{13}-\rho\left[\left(\Omega z_0\sin\frac{\Omega}{c}\,u\right)v_z-\frac{GM}{z^2}+v_t+\Omega^2 z_0\cos\frac{\Omega}{c}\,u\right]=0
\end{aligned}\right\}\qquad(46)$$

where $\rho=\frac{T_{00}}{g_{00}}$, $J^i=\frac{cT_0^i}{\sqrt{g_{00}}}$ and $U^{ik}=c^2T^{ik}$ are the observable projections of the energy-momentum tensor $T_{\alpha\beta}$ of distributed matter. The chr.inv.-conservation equations, taking our assumptions for real experiment into account, take the simplified form

$$\left.\begin{aligned}
&\frac{\partial\rho}{\partial t}+\frac{\partial J^i}{\partial x^i}+\frac{\partial\ln\sqrt{h}}{\partial x^i}\,J^i=0\\
&\frac{\partial J^k}{\partial t}+2A_{i\cdot}^{\cdot k}J^i+\frac{\partial U^{ik}}{\partial x^i}+\frac{\partial\ln\sqrt{h}}{\partial x^i}\,U^{ik}+\\
&\qquad+\Delta_{im}^{k}U^{im}-\rho F^k=0
\end{aligned}\right\}.\qquad(45)$$

Substituting into the equations the formulae for D, D_i^k, $A_{i\cdot}^{\cdot k}$, $\frac{\partial\ln\sqrt{h}}{\partial x^i}$, Δ_{im}^k, and F^k, we obtain a system of the conservation equations (46) wherein we should substitute ρ, J^i, and U^{ik} from the Einstein equations (37) then, reducing similar terms, arrive at some relations between the functions v_t, v_r, v_φ, v_z. The Einstein equations (37) substituted into (46) evidently result in intractable equations. It seems that we will have no chance of solving the resulting equations without some simplification according to real experiment. We should therefore take the simplification into account from the beginning.

First, the scalar equation of the conservation law (44) under the conditions of a real experiment takes the form of (45), which in another notation is

$$\frac{\partial\rho}{\partial t}+{}^*\nabla_i\,J^i=0\,.\qquad(47)$$

The 2nd equation of (37) determines ρ: the quantity is $\rho\sim\frac{1}{c^2}$. Omitting the term proportional to $\frac{1}{c^2}$ as its effect is negligible in a real experiment, we obtain the scalar equation of the conservation law in the form*

$${}^*\nabla_i\,J^i=0\,,\qquad(48)$$

i.e. the chr.inv.-derivative of the common flow of the spatial momentum of distributed matter is zero to within the approximation of a first-order experiment. This finding has a very important meaning:

> Given a space, the non-holonomic background of which is perturbed by an oscillating disc, the common flow of the momentum of distributed matter on the spatial section of such a space is conserved in a first-order experiment.

Second, there are three states of the disc in Podkletnov's experiment: (1) uniform rotation; (2) non-uniform rotation (acceleration/deceleration); (3) non-rotating disc. To study the case of a rotating disc we should introduce, into the metric (25), additional terms which take the rotation into account. We don't do this now, for two reasons: (1) the additional terms introduced into the metric (25) make the equations of the theory too complicated; (2) the case of a non-rotating disc is that main case where, according Podkletnov's experiments, the weight-loss effect appears in the basic form; accelerating/decelerating rotation of the disc produces only additions to the basic weight-loss. So, to understand the origin of the weight-loss phenomenon it is most reasonable to first consider perturbation of the background field of the space non-holonomity by a non-rotating disc. Because such a disc lies horizontally in the plane $r\varphi$ (horizontal plane), we should assume $v_z=0$, while the fact that there $v_r\neq 0$ and $v_\varphi\neq 0$ means freedom for oscillation in the plane $r\varphi$ (accelerating or decelerating twists in the plane) as a result of vertical oscillation of such a disc (otherwise, for no oscillation in the plane $r\varphi$, the conservation equations would become zero). The fact that $\varphi\neq\text{const}$ in the equations means the same.

As a result, the conservation equations (46), with the aforementioned assumptions taken into account, take the form (49). The characteristics of distributed matter such as the momentum flow J^i and the stress-tensor U^{ik}, resulting from

*The chr.inv.-differential operators are completely determined, according to [15, 16], in Appendix 2.

$$\left.\begin{aligned}
&\frac{\partial J^1}{\partial t}-\left[(\cos\varphi+\sin\varphi)\,v_\varphi-r\,(\cos\varphi-\sin\varphi)\,v_r\right]J^2+v_r\,J^3+\frac{\partial U_{11}}{\partial r}+\frac{1}{r^2}\frac{\partial U_{12}}{\partial\varphi}+\frac{1}{r}\left(U_{11}-\frac{U_{22}}{r^2}\right)=0\\
&\frac{\partial J^2}{\partial t}-\left[(\cos\varphi+\sin\varphi)\,\frac{v_\varphi}{r^2}-(\cos\varphi-\sin\varphi)\,\frac{v_r}{r}\right]J^1+\frac{v_\varphi}{r^2}\,J^3+\frac{\partial}{\partial r}\left(\frac{U_{12}}{r^2}\right)+\frac{1}{r^2}\left(\frac{1}{r^2}\frac{\partial U_{22}}{\partial\varphi}+\frac{3}{r}\,U_{12}\right)=0\\
&\frac{\partial J^3}{\partial t}-v_r\,J^1-v_\varphi\,J^2+\frac{\partial U_{13}}{\partial r}+\frac{1}{r^2}\frac{\partial U_{23}}{\partial\varphi}+\frac{1}{r}\,U_{13}=0
\end{aligned}\right\}\qquad(49)$$

$$\left.\begin{aligned}
&\kappa\,J^1=\frac{(\cos\varphi-\sin\varphi)}{2r}\left(v_{r\varphi}-\frac{v_\varphi}{r}\right)-\frac{(\cos\varphi+\sin\varphi)}{2}\left(\frac{v_{\varphi\varphi}}{r^2}+\frac{v_r}{r}\right)\\
&\kappa\,J^2=\frac{1}{2r^2}\left[(\cos\varphi+\sin\varphi)\left(v_{r\varphi}-\frac{v_\varphi}{r}\right)-r\,(\cos\varphi-\sin\varphi)\;v_{rr}\right]\\
&\kappa\,J^3=-\frac{1}{2}\left(v_{rr}+\frac{v_{\varphi\varphi}}{r^2}+\frac{v_r}{r}\right)\\
&\kappa\,U_{11}=\frac{(\cos\varphi-\sin\varphi)}{2}\,v_r^2+(\cos\varphi\sin\varphi)\,\frac{v_\varphi^2}{2r^2}-\frac{\left(\cos^2\varphi-\sin^2\varphi\right)}{2}\frac{v_rv_\varphi}{r}-(\cos\varphi-\sin\varphi)\,\frac{v_{t\varphi}}{r}-\\
&\quad-\frac{2GM}{z^3}-\left(\Omega z_0\sin\frac{\Omega}{c}\,u\right)\left(\frac{v_{\varphi\varphi}}{r^2}+\frac{v_r}{r}\right)\\
&\kappa\,U_{12}=\frac{1}{2}\left[v_rv_\varphi+(\cos\varphi+\sin\varphi)\,v_{t\varphi}+r\,(\cos\varphi-\sin\varphi)\,v_{tr}+2\left(\Omega z_0\sin\frac{\Omega}{c}\,u\right)\left(v_{r\varphi}-\frac{v_\varphi}{r}\right)\right]\\
&\kappa\,U_{13}=\frac{1}{2}\left[v_{tr}-(\cos\varphi-\sin\varphi)\,\frac{v_rv_\varphi}{r}+(\cos\varphi+\sin\varphi)\,\frac{v_\varphi^2}{r^2}\right]\\
&\frac{\kappa\,U_{22}}{r^2}=-(\cos\varphi\sin\varphi)\,\frac{v_r^2}{2}+\frac{(\cos\varphi+\sin\varphi)}{2}\frac{v_\varphi^2}{r^2}-\frac{\left(\cos^2\varphi-\sin^2\varphi\right)}{2}\frac{v_rv_\varphi}{r}-(\cos\varphi+\sin\varphi)\,v_{tr}-\\
&\quad-\frac{2GM}{z^3}-\left(\Omega z_0\sin\frac{\Omega}{c}\,u\right)v_{rr}\\
&\kappa\,U_{23}=\frac{1}{2}\left[v_{t\varphi}+r\,(\cos\varphi-\sin\varphi)\,v_r^2-(\cos\varphi+\sin\varphi)\,v_rv_\varphi\right]\\
&\kappa\,U_{33}=\frac{\cos\varphi\sin\varphi}{2}\left(v_r^2-\frac{v_\varphi^2}{r^2}\right)+\frac{\left(\cos^2\varphi-\sin^2\varphi\right)}{2}\frac{v_rv_\varphi}{r}-(\cos\varphi+\sin\varphi)\,v_{tr}-(\cos\varphi-\sin\varphi)\,\frac{v_{t\varphi}}{r}-\\
&\quad-\left(\Omega z_0\sin\frac{\Omega}{c}\,u\right)\left(v_{rr}+\frac{v_{\varphi\varphi}}{r^2}+\frac{v_r}{r}\right)
\end{aligned}\right\}\qquad(50)$$

the Einstein equations (37), were collected in complete form into the system (37). Under the aforementioned assumptions they take the form (50).

We substitute the respective components of J^i and U^{ik} (50) into the conservation equations (49). After algebra, reducing similar terms, the first two equations of (49) become identically zero, while the third equation takes the form:

$$v_r=\frac{v_\varphi}{r}\,,\qquad(51)$$

The solution $v_r=\frac{v_\varphi}{r}$ we have obtained from the conservation equations satisfies by the function

$$v=B(t)\,r\,e^{\varphi},\qquad(52)$$

where $B(t)$ is a function of time t. Specific formula for the function $B(t)$ should be determined by nature of the phenomenon or the conditions of the experiment.

The solution indicates a dependency between the distributions of v in the r-direction and φ-direction in the space, if the non-holonomic background is perturbed by a disc lying in the $r\varphi$ plane and oscillating in the z-direction.

In other words, the conservation equations in common with the Einstein equations we have obtained mean that:

> A disc, oscillating orthogonally to its own plane, perturbs the field of the background non-holonomity of the space. Such a motion of a disc places a limitation on the geometric structure of the space. The limitation is manifested as a specific distribution of the linear velocity of the space rotation. This distribution means that such a disc should also have small twists in its own plane due to the perturbed non-holonomic background.

$$\left.\begin{aligned}
&\ddot{r}-\big[(\cos\varphi+\sin\varphi)\,v_\varphi-r\,(\cos\varphi-\sin\varphi)\,v_r\big]\,\dot{\varphi}-\big[(\cos\varphi+\sin\varphi)\,v_z-v_r\big]\,\dot{z}-\\
&-(\cos\varphi+\sin\varphi)\,v_t-r\dot{\varphi}^2-\left(\Omega z_0\sin\frac{\Omega}{c}u\right)v_r=0\\
&\ddot{\varphi}+\left[(\cos\varphi+\sin\varphi)\,\frac{v_\varphi}{r^2}-(\cos\varphi-\sin\varphi)\,\frac{v_r}{r}\right]\dot{r}-\left[(\cos\varphi-\sin\varphi)\,\frac{v_z}{r}-\frac{v_\varphi}{r^2}\right]\dot{z}-\\
&-(\cos\varphi-\sin\varphi)\,\frac{v_t}{r}+\frac{2\dot{r}}{r}\,\dot{\varphi}-\left(\Omega z_0\sin\frac{\Omega}{c}u\right)\frac{v_\varphi}{r^2}=0\\
&\ddot{z}+\big[(\cos\varphi+\sin\varphi)\,v_z-v_r\big]\,\dot{r}+\big[r\,(\cos\varphi-\sin\varphi)\,v_z-v_\varphi\big]\,\dot{\varphi}-\\
&+\frac{GM}{z^2}-v_t-\left(\Omega z_0\sin\frac{\Omega}{c}u\right)v_z-\Omega^2 z_0\cos\frac{\Omega}{c}u=0
\end{aligned}\right\} \tag{60}$$

3.5 The geodesic equations in the space. Final conclusion about the forces driving the Podkletnov effect

This is the final part of our mathematical theory of the Podkletnov effect. Here, using the Einstein equations and the equations of the conservation law we have developed, we deduce an additional force that produces the weight-loss effect in Podkletnov's experiment, i.e. the weight-loss over a superconducting disc which is supported in air by an alternating magnetic field.

As is well known, motion in a gravitational field of a free test-particle of rest-mass m_0 is described by the equations of geodesic lines (the geodesic equations). The geodesic equations are, from a purely mathematical viewpoint, the equations of parallel transfer of the four-dimensional vector of the particle's momentum $P^\alpha = m_0\frac{dx^\alpha}{ds}$ along the particle's 4-dimensional trajectory

$$\frac{dP^\alpha}{ds}+\Gamma^\alpha_{\mu\nu}P^\mu\frac{dx^\nu}{ds}=0\,, \tag{53}$$

where $\Gamma^\alpha_{\mu\nu}$ are Christoffel's symbols of the 2nd kind, while ds is the 4-dimensional interval along the trajectory.

The geodesic equations (53), being projected onto the time line and spatial section of an observer, and expressed through the physical observable characteristics of a real laboratory space of a real observer, are known as the chr.inv.-geodesic equations. They were deduced in 1944 by Zelmanov [15, 16]. The related scalar equation is the projection onto the time line of the observer, while the 3-dimensional vector equation is the projection onto his spatial section, and manifests the 3rd Newtonian law for the test-particle:

$$\left.\begin{aligned}
&\frac{dm}{d\tau}-\frac{m}{c^2}F_i\mathrm{v}^i+\frac{m}{c^2}D_{ik}\mathrm{v}^i\mathrm{v}^k=0\\
&\frac{d(m\mathrm{v}^i)}{d\tau}+2m\left(D^i_k+A^{\cdot i}_{k\cdot}\right)\mathrm{v}^k-mF^i+m\Delta^i_{nk}\mathrm{v}^n\mathrm{v}^k=0
\end{aligned}\right\} \tag{54}$$

where m is the relativistic mass of the particle, v^i is the 3-dimensional observable velocity of the particle, and τ is the physical observable or proper time* [15, 16]

$$m=\frac{m_0}{\sqrt{1-\mathrm{v}^2/c^2}}\,,\qquad \mathrm{v}^i=\frac{dx^i}{d\tau}\,, \tag{55}$$

$$d\tau=\sqrt{g_{00}}\,dt+\frac{g_{0i}}{c\sqrt{g_{00}}}\,dx^i=\sqrt{g_{00}}\,dt-\frac{1}{c^2}\,v_i dx^i. \tag{56}$$

With the simplifications for the real experiment we are considering, the chr.inv.-geodesic equations (54) take the form

$$\left.\begin{aligned}
&\frac{dm}{d\tau}=0\\
&\frac{d(m\mathrm{v}^i)}{d\tau}+2mA^{\cdot i}_{k\cdot}\mathrm{v}^k-mF^i+m\Delta^i_{nk}\mathrm{v}^n\mathrm{v}^k=0
\end{aligned}\right\} \tag{57}$$

that is, in component notation,

$$\left.\begin{aligned}
&\frac{dm}{d\tau}=0\\
&\frac{d}{d\tau}\left(m\frac{d\mathrm{v}^1}{d\tau}\right)+2mA^{\cdot 1}_{k\cdot}\mathrm{v}^k-mF^1+m\Delta^1_{22}\mathrm{v}^2\mathrm{v}^2=0\\
&\frac{d}{d\tau}\left(m\frac{d\mathrm{v}^2}{d\tau}\right)+2mA^{\cdot 2}_{k\cdot}\mathrm{v}^k-mF^2+2m\Delta^2_{12}\mathrm{v}^1\mathrm{v}^2=0\\
&\frac{d}{d\tau}\left(m\frac{d\mathrm{v}^3}{d\tau}\right)+2mA^{\cdot 3}_{k\cdot}\mathrm{v}^k-mF^3=0
\end{aligned}\right\} \tag{58}$$

which are actual chr.inv.-equations of motion of a free test-body in the space, whose non-holonomic homogeneous background is perturbed by an oscillating disc.

The scalar geodesic equation of (58) says

$$m=\text{const}\,, \tag{59}$$

so taking this fact into account and introducing the notation $\mathrm{v}^1=\frac{dr}{d\tau}=\dot{r}$, $\mathrm{v}^2=\frac{d\varphi}{d\tau}=\dot{\varphi}$, $\mathrm{v}^3=\frac{dz}{d\tau}=\dot{z}$, we obtain a system of three vector equations of motion of the test-body (60), wherein $v_t=\frac{\partial v}{\partial t}$, $v_r=\frac{\partial v}{\partial r}$, $v_\varphi=\frac{\partial v}{\partial\varphi}$, $v_z=\frac{\partial v}{\partial z}$.

*This is that real time which is registered by the observer in his real laboratory space. Intervals of the physical observable time $d\tau$ and the observable spatial coordinates dx^i are determined, by the theory of physical observable quantities (chronometric invariants) as the projections of the interval of the 4-dimensional coordinates dx^α onto the time line and spatial section of an observer, i.e.: $b_\alpha dx^\alpha = cd\tau$, $h^i_\alpha dx^\alpha = dx^i$ [15, 16]. See Appendix 2 for the details of such a projection.

Because the terms containing z_0 in equations (60) are very small, they can be considered to be small harmonic corrections. Such equations can always be solved using the small parameter method of Poincaré. The Poincaré method is also known as the perturbation method, because we consider the right side as a perturbation of a harmonic oscillation described by the left side. The Poincaré method is related to exact solution methods, because a solution produced with the method is a power series expanded by a small parameter (see Lefschetz, Chapter XII, §2 of [21]).

However our task is much simpler. We are looking for an approximate solution of the system of the vector equations of motion in order to see the main forces acting in the basic Podkletnov experiment. We therefore simplify the equations as possible. First we take into account that, in the condition of Podkletnov's experiment, the suspended test-body has freedom to move only in the z-direction (i.e. up or down in a vertical direction, which is the direction of the acting force of gravity). In other words, concerning a free test-body falling from above the disc, we take $\dot{r}=0$ and $\dot{\varphi}=0$ despite the forces $\ddot{r}$ and $\ddot{\varphi}$ acting it in the r-direction and the φ-direction are non-zero. Second, rotational oscillation of the disc in the $r\varphi$–plane is very small. We therefore regard φ as a small quantity, so $\sin\varphi\simeq\varphi$ and $\cos\varphi\simeq 1$. Third, by the conservation equations, $v_\varphi = r\,v_r$.

Taking all the assumptions into account, the equations of motion (60) take the much simplified form

$$\left.\begin{aligned} &\ddot{r} + v_r\dot{z} - (1+\varphi)\,v_t - \left(\Omega z_0 \sin\frac{\Omega}{c}u\right)v_r = 0\\ &\ddot{\varphi} + \frac{v_r}{r}\,\dot{z} - (1-\varphi)\,v_t - \left(\Omega z_0 \sin\frac{\Omega}{c}u\right)\frac{v_r}{r} = 0\\ &\ddot{z} + g - v_t - \Omega^2 z_0 \cos\frac{\Omega}{c}u = 0 \end{aligned}\right\} \qquad (61)$$

where $g=\frac{GM}{z^2}$ is the acceleration produced by the Earth's force of gravity, remaining constant for the experiment.

For Podkletnov's experiment, $v_t = \text{const}$, and this value depends on the specific parameters of the vertically oscillating disc, such as its diameter, the frequency and amplitude of its vibration. The harmonic term in the third equation is a small correction which can only shake a test-body in the z-direction; this term cannot be a source of a force acting in just one direction. Besides, the harmonic term has a very small numerical value, and so it can be neglected. In such a case, the third equation of motion takes the simple form

$$\ddot{z} + g - v_t = 0\,, \qquad (62)$$

where the last term is a correction to the acting force of gravity due to the perturbed field of the background space non-holonomity.

Integrating the equation $\ddot{z} = -g + v_t$, we obtain

$$z = -\frac{g - v_t}{2}\,\tau^2 + C_1\tau + C_2\,, \qquad (63)$$

where the initial moment of time is $\tau_0 = 0$, the constants of integration are $C_1 = \dot{z}_0$ and $C_2 = z_0$. As a result, if the test-body is at rest at the initial moment of time ($\dot{z}_0 = 0$), its vertical coordinate z at another moment of observable time is

$$z = z_0 - \frac{g\tau^2}{2} + \frac{v_t\tau^2}{2}\,. \qquad (64)$$

The result we have obtained isn't trivial because the additional forces obtained within the framework of our theory originate in the field of the background space non-holonomity perturbed by the disc. As seen from the final equation of motion along the z-axis (62), such an additional force acts everywhere against the force of gravity. So it works like "negative gravity", a truly *anti-gravity force*.

Within the framework of Classical Mechanics we have no space-time, hence there are no space-time terms in the metrics which determine the non-holonomity of space. So such an anti-gravity force is absent in Classical Mechanics.

Such an anti-gravity force vanishes in particular cases of General Relativity, where the pseudo-Riemannian space is holonomic, and also in Special Relativity, where the pseudo-Riemannian space is holonomic by definition (in addition to the absence of curvature, gravitation, and deformation).

So the obtained anti-gravity force appears only in General Relativity, where the space is non-holonomic.

It should be noted that the anti-gravity force $F = mv_t$ isn't related to a family of forces of inertia. Inertial forces are fictitious forces unrelated to a physical field; an inertial force appears only in mechanical contact with that physical body which produces it, and disappears when the mechanical connexion ceases. On the contrary, the obtained anti-gravity force originates from a real physical field — a field of the space non-holonomity, — and is produced by the field in order to compensating for the perturbation therein. So the anti-gravity force obtained within the framework of our theory is a real physical force, in contrast to forces of inertia.

Concerning Podkletnov's experiment, we should take into account the fact that a balance suspended test-body isn't free, due to the force of reaction of the pier of the balance which completely compensates for the common force of attraction of the test-body towards the Earth (the body's weight). As a result such a test-body moves along a non-geodesic world-trajectory, so the equations of motion of such a particle have non-zero right side containing the force of the reaction of the pier. In the state of static weight, the common acceleration of the test-body in the z-direction is zero ($\ddot{z}=0$), hence its weight Q is

$$Q = mg - mv_t\,. \qquad (65)$$

The quantity v_t contained in the additional anti-gravity force $F = mv_t$ is determined by the parameters of the small twists of the disc in the horizontal plane, the frequency of which is the same as the frequency Ω of vertical oscillation of the disc, while the amplitude depends on parameters of the disc, such as its radius r and the amplitude z_0 of the oscillation. (A calculation for such an anti-gravity force in the condition of a real experiment is given in the next Section. As we will see, our theory gives good coincidence with the weight-loss effect as measured in Podkletnov's experiment.)

The geodesic equation we have obtained in the field of an oscillating disc allows us to draw a final conclusion about the origin of the forces which drive the weight-loss effect in Podkletnov's experiment:

> A force produced by the field of the background space non-holonomity, compensating for a perturbation therein, works like *negative gravity* in the condition of an Earth-bound experiment. Being produced by a real physical field that bears its own energy and momentum, such an anti-gravity force is a real physical force, in contrast to fictitious forces of inertia which are unrelated to physical fields.
>
> In the conditions of Podkletnov's experiment, a horizontally placed superconducting disc, suspended in air due to an alternating magnetic field, undergoes oscillatory bounces in a vertical direction (orthogonal to the plane of the disc) with the same frequency of the magnetic field. Such an oscillation perturbs the field of the background space non-holonomity, initially homogeneous. As a result the background non-holonomity field is perturbed in three spatial directions, including the horizontal plane (the plane of the disc), resulting in small amplitude oscillatory twists about the vertical direction. The oscillatory twists determine the *anti-gravity force*, produced by the perturbed field of the background space non-holonomity, and act in the vertical directing against the force of gravity. Any test-body, placed in the perturbed non-holonomity field above such a vertically oscillating disc, should experience a loss in its weight, the numerical value of which is determined by the parameters of the disc and its oscillatory motion in the vertical direction. If such a disc rotates with acceleration, this should be the source of an addition perturbation of the background non-holonomity field and, hence, a substantial addition to the weight-loss effect should be observed in experiment. (Uniform rotation of the disc should give no effect.)

Herein we have been concerned with only a theory of a phenomenon discovered by Podkletnov (we refer to this as the *Podkletnov effect*, to fix the term in scientific terminology).

According to our theory, superconductor technology accounts in Podkletnov's experiment only for levitation of the disc and driving it into small amplitude oscillatory motion in the vertical direction. However, it is evident that this isn't the only way to achieve such a state for the disc.

Furthermore, we show that there are also both mechanical and nuclear systems which can simulate the Podkletnov effect and, hence, be the sources of continuous and explosive energy from the field of the background space non-holonomity.

Such a mechanical system, simulating the conditions of the Podkletnov effect, provides a possibile means of continuous production of energy from the space non-holonomity field. At the same time we cannot achieve high numerical values of the oscillatory motion in a mechanical system, so the continuous production of energy might be low (althopugh it may still reach useful values).

On the contrary, processes of nuclear decay and synthesis, due to the instant change of the spin configuration among nucleons inside nuclei, should have high numerical values of v_t, and therefore be an explosive source of energy from the field of the background space non-holonomity.

Both mechanical and nuclear simulations of the Podkletnov effect can be achieved in practice.

4 A new experiment proposed on the basis of the theory

4.1 A simple test of the theory of the Podkletnov effect (alternative to superconductor technology)

According our theory, the Podkletnov effect has a purely mechanical origin, unrelated to superconductivity — the field of the background space non-holonomity being perturbed by a disc which undergoes oscillatory bounces orthogonal to its own plane, produces energy and momentum flow in order to compensate for the perturbation therein. Owing to this, we propose a purely mechanical experiment which reproduces the Podkletnov effect, equivalent to Podkletnov's original superconductor experiment, which would be a cheap alternative to costly superconductor technology, and also be a simple mechanical test of the whole theory of the effect.

What is the arrangement of such a purely mechanical system, which could enable reproduction of the Podkletnov effect? Searching the scientific literature, we found such a system. This is the *vibration balance* [22], invented and tested in the 1960–1970's by N. A. Kozyrev, a famous astronomer and experimental physicist of the Pulkovo Astronomical Observatory (St. Petersburg, Russia). Below is a description of the balance, extracted from Kozyrev's paper [22]:

> "The vibration balance is an equal-shoulder balance, where the pier of the central prism is connected to a vibration machine. This vibration machine produces vertical vibration of the pier. The acceleration of the vibration is smaller than the acceleration of the Earth's gravitation. Therefore the prism doesn't lose contact with the pier, only alternating pressure results. Thus the distance between the centre of gravity and the cone of the prism remains constant while the weight and the balance don't change their own measurement precision. The vertical guiding rods, set up along the pier, exclude the possibility of horizontal motion of the pier. One of two samples of the same mass is rigidly suspended by the yoke of the balance, while the second sample is suspended by an elastic material. Here the force required to lift the yoke is just a small percentage of the force required to lift the rigidly fixed sample. Therefore, during vibration of the balance, there is stable kinematic of the yoke, where the point O (the point of hard suspension)

doesn't participate in vibration, while the point A (the point of elastic suspension) has maximal amplitude of oscillation which is double the amplitude of the central prism C. Because the additional force, produced during vibration, is just a few percent more than the static force, the yoke remains fixed without inner oscillation, i.e. without twist, in accordance with the requirement of static weight.

We tested different arrangements of balances under vibration. The tested balances had different sensitivities, while the elastic material was tried with rubber, a spring, etc. Here is detailed a description of the vibration balance which is currently in use. This is a technical balance of the second class of sensitivity, with a maximum payload of 1 kg. A 1 mm deviation of the measurement arrow, fixed on the yoke, shows a weight of 10 mg. The centre of gravity of the yoke is located $\sim$1 cm below the pier of the central prism. The length of the shoulders of the yoke is: $\mathrm{OC} = \mathrm{CA} = l = 16$ cm. The amplitude of vibration is $a \approx 0.2$ mm. Thus the maximum speed of the central prism is $v = \frac{2\pi}{T}a \simeq 2$ cm/sec, while its maximum acceleration $\left(\frac{2\pi}{T}\right)^2 a = 2\times10^2$ is about 20% of the acceleration of the Earth's gravitation. We regularly used samples of 700 g. One of the samples was suspended by a rubber, the strain of which for 1 cm corresponds 100 g weight. So, during vibration, the additional force on the yoke is less than 10 g and cannot destroy the rigidity of the yoke. The elastic rubber suspension absorbs vibration so that the sample actually rests.

This balance, as well as all recently tested systems, showed each time the increase of the weight of the elastically suspended sample. This additional force $\triangle Q$ is proportional to the weight of the sample Q, besides $\triangle Q/Q = 3\times10^{-5}$. Hence, having $Q = 700$ g, $\triangle Q = 21$ mg and the force momentum twisting the yoke is 300 dynes$\times$cm.

[...] From first view one can think that, during such a vibration, the pier makes twists around the resting point O. In a real situation the points of the pier are carried into more complicated motion. The central prism doesn't lose contact with the pier; they are connected, and move only linearly. Therefore the central part of the yoke, where its main mass is concentrated, has no centrifugal acceleration. What is about the point O, this point in common with the rigidly suspended sample is fixed in only the vertical direction, but it can move freely in the horizontal direction. These horizontal displacements of the point O are very small. Naturally, they are $\frac{a^2}{2l}$, i.e. $\sim$0.1 μm in our case. Despite that, the small displacements result a very specific kinematic of the yoke. During vibration, each point of the yoke draws an element of an ellipse, a small axis of which lies along the yoke (in the average position of it). The concavities of the elements in the yoke's sections O–C and C–A are directed opposite to each other; they produce oppositely directed centrifugal forces. Because $\bar{v}^2$ is greater in the section C–A, the centrifugal forces don't compensate each other completely: as a result there in the yoke a centrifugal force acts in the A-direction (the direction at the point of the elastically suspended sample). This centrifugal acceleration has maximum value at the point A. We have $\bar{v}^2 = \frac{4\pi^2}{T^2}a^2 = 6$ cm^2/sec^2. From here we obtain the curvature radius of the ellipse: $\rho = 4l = 60$ cm. So the centrifugal acceleration is $\frac{\bar{v}^2}{\rho} = 0.1$ cm/sec^2."

Such a vibration balance is shown in the upper picture of Fig. 4. An analogous vibration balance is shown in the lower picture of Fig. 4: there the vibration machine is connected not to the pier of the central prism, but to he elastic suspension, while the prism's pier is supported by a spring; such a system should produce the same effect.

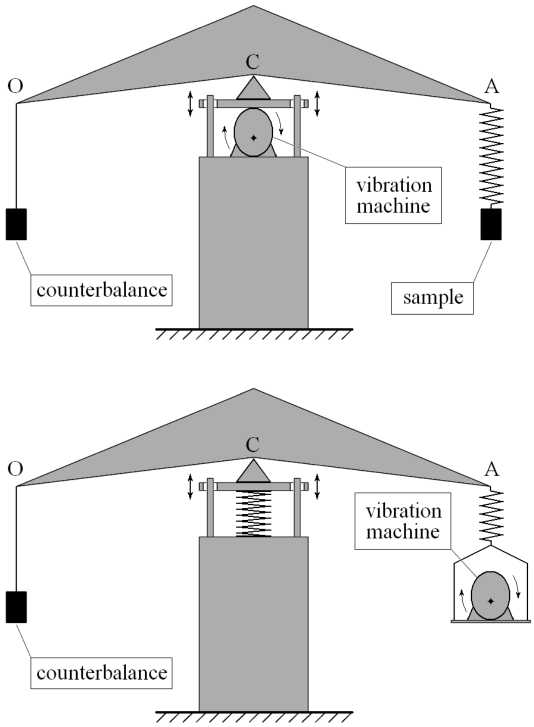

Fig. 4: The vibration balance — a mechanical test of the whole theory of the Podkletnov effect (a simple alternative to costly superconductor technology).

To understand how the Podkletnov effect manifests with the vibration balance, we consider the operation of the balance in detail (see Fig. 5).

The point O of the yoke undergoes oscillatory bounces in the r-direction with the amplitude d, given by

$$d = l - l\cos\alpha = l - l\sqrt{1-\sin^2\!\alpha} = l - l\sqrt{1-\frac{a^2}{l^2}} \simeq l - l\left(1-\frac{a^2}{2l^2}\right) \simeq \frac{a^2}{2l}\,, \qquad (66)$$

while b is

$$b = d\tan\alpha = d\,\frac{a}{l\cos\alpha} \simeq \frac{a^3}{2l^2\left(1-\frac{a^2}{2l^2}\right)} \simeq \frac{a^3}{2l^2-a^2}\,. \qquad (67)$$

The point A undergoes oscillatory bounces in the z-direction with the amplitude $2a$, while its oscillatory motion in the r-direction has the amplitude

$$c = 2l - 2l\cos\alpha - d = d\,. \qquad (68)$$

The oscillatory bouncing of the points O and A along the elements of an ellipse is an accelerating/decelerating rotational motion around the focus of the ellipse. In such a case, by definition of the space non-holonomity as the non-orthogonality of time lines to the spatial section, manifest

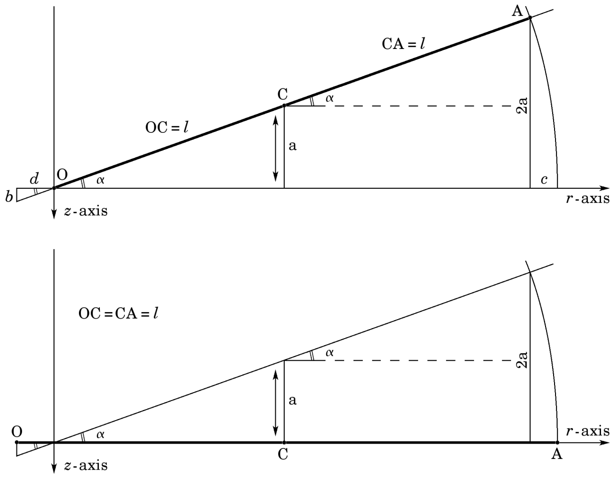

Fig. 5: The yoke of the vibration balance in operation. The yoke OA is indicated by the bold line. The double arrow shows the oscillatory bouncing motion of the point C, which is the point of connexion of the central prism and the central point of the yoke. The lower picture shows the yoke in its initial horizontal position. The upper picture shows the yoke in the upper position, at maximum deviation from the state of equilibrium.

as a three-dimensional rotation, points O and A during the oscillatory motion along respective elliptic elements, are the *source of a local field of the space non-holonomity*. Respective tangential accelerations $\bar{v}_t$ at the points O and A determine the sources.

Given that the background space is non-holonomic, such a field of the local non-holonomity is a *perturbation field* in the non-holonomic background. In other words, points O and A, in common with the respective samples mechanically connected to the points, are the sources of respective perturbation fields in the background field of the space non-holonomity.

Each point of the yoke, being carried into such an oscillatory motion, is the source of such a perturbation field. On the other hand, the average tangential acceleration of the motion, $\bar{v}_t$, takes its maximum value at the point A, then substantially decreases to the point O where it is negligible. Therefore such a yoke can be approximated as a non-symmetric system, where the end-point A is the source of a perturbation field in the non-holonomic background, while the end-point O isn't such a source.

According to the Einstein equations we have obtained in (35), the energy and momentum of a perturbation field in the non-holonomic background are produced by the whole field of the background space non-holonomity in order to compensate for the perturbation therein*. So the energy produced on a test-body in such a perturbation field isn't limited by the energy of the source of the perturbation (an oscillator, for instance), but can increase infinitely.

According to the geodesic equations (61) we have obtained in a perturbed non-holonomic field, the momentum of such a perturbation field manifests as the additional forces which act in all three directions r, φ, z relative to the source of the perturbation. If considering a free test-body constrained to move only along only the Earth's gravitational field-lines (falling freely in the z-direction), such an add-on force is expressed in the geodesic equation along the z-axis (62)

$$\ddot{z} + g - v_t = 0 \tag{69}$$

as $F = m v_t$, and works against the force of gravity mg. In the situation of a static weight the total acceleration of such a sample is zero, $\ddot{z} = 0$, while the other forces are put into equilibrium by the weight of the sample (65)

$$Q = mg - m v_t = Q_0 - \triangle Q\,. \tag{70}$$

A source of perturbation cannot be an object of application of a force produced due to the perturbation. Therefore the sample O is the object of application of an anti-gravity force $F = m v_t$ due to a field of the anti-gravity accelerations v_t, a source of which is the oscillatory bouncing system of the point A in common with the elastically suspended sample, while the point A itself in common with the sample has no such anti-gravity force applied to it. As a result the weight of the sample rigidly suspended at the end-point O, decreases as $\triangle Q = m v_t$, while the weight of the sample A remains the same:

$$Q_{\text{O}} = mg - m v_t\,, \qquad Q_{\text{A}} = mg\,. \tag{71}$$

As a result, such a balance, during its vibration, should demonstrate a weight-loss of the rigidly suspended sample O and, respectively, a twist of the balance's yoke to the elastically suspended sample A. Such a weight-loss effect on the rigidly suspended sample, which is a fictitious increase of the weight of the elastically suspended sample, was first observed during the years 1960–1970's in the pioneering experiment of Kozyrev [22].

The half-length horizontal section of a superconducting disc suspended in air by an alternating magnetic field in Podkletnov's experiment (see Fig. 2) can be approximated by the yoke of the aforementioned vibrational balance. This is because the vertical oscillation of such a disc by an alternating magnetic field isn't symmetric in the disc's plane, so such a disc has a small oscillatory twisting motion in the vertical plane to the yoke of the vibration balance†.

*Note that we deduced the Einstein equations (35) for a space pervaded not only by an electromagnetic field, but also by distributed matter characterised by arbitrary properties. If only an electromagnetic field, there would be $\rho c^2 = U$. However $\rho c^2 - U \neq 0$ in the Einstein equations (35). This can be due to a number of reasons, the presence of an elastic force which compresses a spring, for instance. Therefore the Einstein equations we have obtained (35) are applicable to a laboratory space containing such a vibration balance.

†This is despite the fact that such a disc has so small an amplitude and so high a frequency of oscillatory twisting motion, that it seems to be levitating when almost at rest.

As a result, such a disc should experience the anti-gravity force $F = mv_t$ at the end-points of the disc, along the whole perimeter. Common action of the forces should produce:

1. The weight-loss effect $\triangle Q = mv_t$ on the disc itself. The weight-loss of the disc should increase if the disc has accelerating/decelerating rotation;
2. Respective weight-loss effect on any test-body located over the disc along the vertical axis z, according to the field of anti-gravity accelerations v_t.

Therefore the disc in Podkletnov's experiment and a vibration balance of the aforementioned type are equivalent systems. So both the superconductor experiment and the vibration balance should be described by the same theory we have adduced herein, and produce the same weight-loss effect as predicted by the theory.

The numerical value of such an anti-gravity acceleration, v_t, can also be calculated within the framework of our theory of the Podkletnov effect, and thus checked in experiment.

According to our theory, the value v of the perturbation isn't dependent on the vertical direction (the z-direction in our coordinates). Therefore only the horizontal oscillatory bouncing motion of point A (in common with the sample rigidly suspended there) perturbs the background field of the space non-holonomity. According to Fig. 5, the tangential acceleration of the point A in its oscillatory motion with amplitude $2a$ along an ellipse with the radius $\rho = 4l$, is directed in the z-direction. So the tangential acceleration cannot perturb the non-holonomic background. However there is another tangential acceleration of the point A, which results from the oscillatory motion of the point with the amplitude c (numerically $c = d$) around the upper location of the point A. This tangential acceleration is directed along the r-axis, so it is the source of a local perturbation in the non-holonomic background. The angle of the small twist at the point A during such an oscillation is $\varphi = \frac{d}{2\pi a} = \frac{a}{4\pi l}$, so the average angular acceleration of the motion is $\bar{\ddot{\varphi}} = \frac{1}{2}\ddot{\varphi} = \frac{\Omega^2 a}{8\pi l}$. The average tangential acceleration of the motion, directed in the r-direction, is $\bar{v}_t = 2a\bar{\ddot{\varphi}}$, i.e.

$$\bar{v}_t = \frac{\Omega^2 a^2}{4\pi l} = \frac{\pi \nu^2 a^2}{l}\,, \tag{72}$$

which characterizes, according to the definition of the space non-holonomity, the local perturbation in the background field of the space non-holonomity.

Consider a vibration balance like that in Kozyrev's original experiment [22]. Each shoulder of the yoke has the length $l = 16$ cm, so the total length of the yoke is 32 cm. Let the central prism of the balance undergo oscillatory bounces in the vertical direction with an amplitude of $a = 0.020$ cm, so the amplitude of the point A is $2a = 0.040$ cm. One of the samples is rigidly suspended at point O of the yoke, while the other sample is suspended at point A by an elastic medium. Both samples have the same mass: 700 g. According to our theory, the Podkletnov effect should appear in the balance as a weight loss $\triangle Q$ of the sample O, dependent on the frequency as follows:

ν, Hz	v_t, cm/sec^2	$\triangle Q/Q$	$\triangle Q$, mg	$\triangle Q_{\rm exp}$, mg
30	0.071	7.2×10^{-5}	50	
25	0.049	5.0×10^{-5}	35	
20	0.031	3.2×10^{-5}	22	21
15	0.018	1.8×10^{-5}	13	
10	0.0079	8.0×10^{-6}	5.6	

Table 1: The weight-loss effect, calculated with our theory of the Podkletnov effect, for a vibration balance with the same characteristics as that of Kozyrev's pioneering experiment [22]. The last column gives the numerical value of the weight-loss effect observed in Kozyrev's experiment, at a constant frequency of 20 Hz.

Kozyrev measured $\triangle Q = 21$ mg at a fixed frequency of $\nu = 20$ Hz in his experiment [22]. This corresponds with $\triangle Q = 22$ mg predicted by our theory*.

For Podkletnov's experiment, we haven't enough data for the amplitude of oscillatory bouncing motion of the superconductor disc. Despite this, we can verify our theory of the phenomenon in another way, due to the fact that Podkletnov observed a dependence of the weight-loss effect on the oscillation frequency.

Although dependency on frequency was observed in each of Podkletnov's experiments, we only have detailed data for the 1997 experiment, from publication [2]. We give in Table 2 Podkletnov's experimental values of $\triangle Q/Q$, measured on a sample located in the field of a 275/80 × 10 mm superconductor toroid at vibration frequencies of the toroid from 3.1 MHz to 3.6 MHz and the constant rotation speed 4300 rpm. The last column gives the increasing values of $\triangle Q/Q$, calculated by our theory where the weight-loss effect should be dependent on the square of the vibration frequency:

ν, MHz	$(\triangle Q/Q)_{\rm exp}$	$(\triangle Q/Q)_{\rm theor}$
3.1	2.2×10^{-3}	
3.2	2.3×10^{-3}	2.3×10^{-3}
3.3	2.4×10^{-3}	2.5×10^{-3}
3.4	2.6×10^{-3}	2.6×10^{-3}
3.5	2.9×10^{-3}	2.8×10^{-3}
3.6	3.2×10^{-3}	3.0×10^{-3}

Table 2: The increase of the weight-loss effect $(\triangle Q/Q)_{\rm exp}$ with vibration frequency ν, measured in Podkletnov's experiment of 1997 [2], in comparison to the value $(\triangle Q/Q)_{\rm theor}$ calculated by our theory of the phenomenon.

*We should also add that, coming from the geodesic equation along the z-axis, which is the third equation of (61), to the simplified form (62) thereof, we omitted the harmonic term from consideration. If the term is included, the vibration balance experiment should reveal not only an increase of the weight-loss effect with the frequency, but also resonant levels in it. The resonant levels, in further experiment, would be an additional verification of our theory.

We see that our theory is in very close accord with Podkletnov's experimental data. Furthermore, according to Podkletnov [2], despite the high measurement precision of the balance used in his experiment, some error sources produced systematic error in the order of 10^{-3} during the experiment. Taking this into account, we conclude that our theory is *sufficiently coincident* with Podkletnov's experimental data.

Podkletnov observed a decrease of the air pressure over the working device in the laboratory, and also a force distributed in a radial direction. We point out that the geodesic equations (61) obtained within the framework of our theory show forces, aside for the vertically acting anti-gravity force (i.e. acting in the z-direction), acting in the directions r and φ as well, produced by the perturbed field of the space non-holonomity. We therefore interpret Podkletnov's observations as a qualitative verification of our theory.

Podkletnov measured a much greater weight-loss effect over a disc during its accelerating/braking rotation. We haven't developed a theory for a rotating disc yet. Despite that, by analogy with our theory for a non-rotating disc, we can qualitatively predict that a field of the anti-gravity acceleration v_t produced by a rotating disc should be proportional to the radius of the disc and its angular acceleration, in accordance with the fact that Podkletnov's experiment is very difficult to reproduce on small discs, diameter about $1''$. Following Podkletnov, the weight-loss effect will be surely measured on a disc of at least $5''$ diameter.

Finally, complete verification of our theory of the Podkletnov effect should usher in new experimental checks for the frequency dependency of the weight-loss, which should appear in both the vibration balance and the Podkletnov superconductor device. With a new vibration balance experiment and a superconductor experiment confirming the frequency dependency according to (72), our theory of the Podkletnov effect would be completely verified.

4.2 New energy sources and applications to space travel

Due to the predictions of our theory, we have the possibility of the Podkletnov effect on such a simple device as the vibration balance, which is a thousand times cheaper and accessible than superconductor technology. In other words, being armed with the theory, it is more reasonable to use the weight-loss effect in practice with other devices which, working on principles other than the Podkletnov superconductor device, could easily reproduce the effect in both an Earth-bound laboratory and in space.

On the basis of our theory, new engineering applications such as anti-gravity devices and devices which could be used as new sources of energy, might be developed.

Anti-gravity engines for air and space travel. There can be at least two kinds of such engines, projected on the basis of our theory:

1. Land-based engines, which produce a strong anti-gravity acceleration field due to the Podkletnov effect. The anti-gravity acceleration field doesn't depend on the vertical distance from the disc, which generates it in Podkletnov's experiment. Due to this fact, a land-based engine, producing a beam of the anti-gravity acceleration field focused on a flying apparatus, can be used by the flying vehicle as a power station. The anti-gravity acceleration in the beam becomes the same as the acceleration of free fall. There can be limitation only from the scattering of the beam with distance. So such a land-based engine is suitable for short distances used in air travel*;
2. Engines located on board of a flying vehicle, that can be more suitable for both air and space travel. Such an engine, being the source of a field of the anti-gravity acceleration, cannot be the subject of application of the anti-gravity force produced in the field. However the force applies to the other parts of the apparatus, as in the vibration balance experiment or Podkletnov's experiment.

We note that in both cases, it isn't necessary to use a purely mechanical kernel for such an engine, as for the vibration balance experiment and Podkletnov's experiment considered in this paper. Naturally, using a mechanical oscillatory bouncing motion or accelerating/braking rotation, the maximum acceleration in the generated anti-gravity field is limited by the shock resistance of the mechanical aspects of the engine. This substantial limitation can be overcome if instead of solid bodies, liquids (liquid metal like mercury, for instance) or liquid crystals are driven into such motion by high frequency electromagnetic fields.

Devices which could be the source of new energy. This is another application of our theory, the experimental realization of which differs from the vibration balance experiment and Podkletnov's experiment. According to our theory, the coupling energy between the nucleons in a nucleus should be different due to the Podkletnov effect depending on the common orientation of the nucleons' spins in the nucleus. As a result, we could have a large explosive production of energy during not only self-decay of heavy elements like uranium and the trans-uraniums, but also by destroying the nuclei of the lightweight elements located in the middle of the Periodic Table of Elements. Of course, not just any nucleus will be the source of such energy production, but only those where, by our theory, the Podkletnov effect works, due to the specific orientation of the spins in the strong interaction amongst the nucleons.

Such an energy source, being free of deadly radiation or radioactive waste, could be a viable alternative to nuclear power plants.

*This kind of anti-gravity engine was first proposed in 2006 by Eugene Podklenov, in his interview [8].

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Appendix 1 The space non-holonomity as rotation

How is the non-orthogonality of the coordinate axes expressed by the components of the fundamental metric tensor $g_{\alpha\beta}$? To show this there are a few ways [14]. We use a formal method developed by Zelmanov [15]. First, we introduce a *locally geodesic reference frame* at a given point of the Riemannian space. Within infinitesimal vicinities of any point of such a reference frame the fundamental metric tensor is

$$\tilde{g}_{\alpha\beta} = g_{\alpha\beta} + \frac{1}{2}\left(\frac{\partial^2 \tilde{g}_{\alpha\beta}}{\partial \tilde{x}^\mu \partial \tilde{x}^\nu}\right)(\tilde{x}^\mu - x^\mu)(\tilde{x}^\nu - x^\nu) + \dots ,$$

i. e. the components at a point, and in its vicinity, are different from those at the point of reflection to within only the higher order terms, the values of which can be neglected. Therefore, at any point of a locally geodesic reference frame the fundamental metric tensor can be considered constant, while the first derivatives of the metric (the Christoffel symbols) are zero.

As a matter of fact, within infinitesimal vicinities of any point located in a Riemannian space, a locally geodesic reference frame can be set up. At the same time, at any point of this locally geodesic reference frame a tangentially flat Euclidean space can be set up so that this reference frame, being locally geodesic for the Riemannian space, is the global geodesic for that tangential flat space.

The fundamental metric tensor of a flat Euclidean space is constant, so the values of $\tilde{g}_{\mu\nu}$, taken in the vicinity of a point of the Riemannian space, converge to the values of the tensor $g_{\mu\nu}$ in the flat space tangential at this point. Actually, this means that we can build a system of basis vectors $\vec{e}_{(\alpha)}$, located in this flat space, tangential to curved coordinate lines of the Riemannian space.

In general, coordinate lines in Riemannian spaces are curved, inhomogeneous, and are not orthogonal to each other. So the lengths of the basis vectors may sometimes be very different from unity.

We denote a four-dimensional infinitesimal displacement vector by $d\vec{r} = (dx^0, dx^1, dx^2, dx^3)$, so that $d\vec{r} = \vec{e}_{(\alpha)}dx^\alpha$, where components of the basis vectors $\vec{e}_{(\alpha)}$ tangential to the coordinate lines are $\vec{e}_{(0)} = \{e^0_{(0)}, 0, 0, 0\}$, $\vec{e}_{(1)} = \{0, e^1_{(1)}, 0, 0\}$, $\vec{e}_{(2)} = \{0, 0, e^2_{(2)}, 0\}$, $\vec{e}_{(3)} = \{0, 0, 0, e^2_{(3)}\}$. The scalar product of the vector $d\vec{r}$ with itself is $d\vec{r}d\vec{r} = ds^2$. On the other hand, the same quantity is $ds^2 = g_{\alpha\beta}\,dx^\alpha dx^\beta$. As a result we have

$$g_{\alpha\beta} = \vec{e}_{(\alpha)}\vec{e}_{(\beta)} = e_{(\alpha)}e_{(\beta)}\cos\left(x^\alpha; x^\beta\right),$$

so we obtain

$$g_{00} = e^2_{(0)}\,,$$
$$g_{0i} = e_{(0)}e_{(i)}\cos\left(x^0; x^i\right),$$
$$g_{ik} = e_{(i)}e_{(k)}\cos\left(x^i; x^k\right).$$

The gravitational potential is $\mathrm{w} = c^2(1 - \sqrt{g_{00}})$. So the time basis vector $\vec{e}_{(0)}$ tangential to the time line $x^0 = ct$, having the length

$$e_{(0)} = \sqrt{g_{00}} = 1 - \frac{\mathrm{w}}{c^2}\,,$$

is smaller than unity the greater the gravitational potential w.

The space rotation linear velocity $v_i = -\frac{c\,g_{0i}}{\sqrt{g_{00}}}$ and, according to it, the chr.inv.-metric tensor $h_{ik} = -\,g_{ik} + \frac{g_{0i}\,g_{0k}}{g_{00}}$ gives

$$v_i = -\,c\,e_{(i)}\cos\left(x^0; x^i\right),$$
$$h_{ik} = e_{(i)}e_{(k)}\Big[\cos\left(x^0; x^i\right)\cos\left(x^0; x^k\right) - \cos\left(x^i; x^k\right)\Big].$$

Appendix 2 A short tour of chronometric invariants

Determination of physical observable quantities in General Relativity isn't a trivial problem. For instance, for a four-dimensional vector Q^α we may heuristically assume that its three spatial components form a three-dimensional observable vector, while the temporal component is an observable potential of the vector field (which generally doesn't prove they can be actually observed). However a contravariant tensor of the 2nd rank $Q^{\alpha\beta}$ (as many as 16 components) makes the problem much more indefinite. For tensors of higher rank the problem of heuristic determination of observable components is more complicated. Besides, there is an obstacle related to definition of observable components of covariant tensors (in which the indices are subscripts) and of mixed tensors, which have both subscripts and superscripts. Therefore the most reasonable way out of the labyrinth of heuristic guesses is to create a strict mathematical theory to enable calculation of observable components for any tensor quantities.

A complete mathematical apparatus to calculate physical observable quantities for a four-dimensional pseudo-Riemannian space was completed in 1944 by Abraham Zelmanov [15]: that is the strict solution of the problem. He called the apparatus the *theory of chronometric invariants*. Many researchers were working on the problem in the 1930–1940's. Even Landau and Lifshitz in their famous book *The Classical Theory of Fields* (1939) introduced observable time and the observable three-dimensional interval similar to those introduced by Zelmanov. But they limited themselves only to this particular case and did not arrive at general mathematical methods to define physical observable quantities in pseudo-Riemannian spaces.

The essence of Zelmanov's theory is that if an observer accompanies his physical reference body, his observable quantities are projections of four-dimensional quantities on his time line and the spatial section — *chronometrically invariant quantities*, made by projecting operators

$$b^\alpha = \frac{dx^\alpha}{ds}\,, \qquad h_{\alpha\beta} = -\,g_{\alpha\beta} + b_\alpha b_\beta\,,$$

which fully define his real reference space (here b^α is his velocity with respect to his real references). Thus, the chr.inv.-projections of a world-vector Q^α are

$$b_\alpha Q^\alpha = \frac{Q_0}{\sqrt{g_{00}}}\,, \qquad h^i_\alpha Q^\alpha = Q^i,$$

while chr.inv.-projections of a world-tensor of the 2nd rank $Q^{\alpha\beta}$ are

$$b^\alpha b^\beta Q_{\alpha\beta} = \frac{Q_{00}}{g_{00}}\,, \quad h^{i\alpha}b^\beta Q_{\alpha\beta} = \frac{Q^i_0}{\sqrt{g_{00}}}\,, \quad h^i_\alpha h^k_\beta Q^{\alpha\beta} = Q^{ik}.$$

Physically observable properties of the space are derived from the fact that chr.inv.-differential operators

$$\frac{^*\partial}{\partial t} = \frac{1}{\sqrt{g_{00}}}\frac{\partial}{\partial t}\,, \qquad \frac{^*\partial}{\partial x^i} = \frac{\partial}{\partial x^i} + \frac{1}{c^2}\,v_i\,\frac{^*\partial}{\partial t}$$

are non-commutative

$$\frac{^*\partial^2}{\partial x^i\,\partial t} - \frac{^*\partial^2}{\partial t\,\partial x^i} = \frac{1}{c^2}\,F_i\,\frac{^*\partial}{\partial t}\,, \quad \frac{^*\partial^2}{\partial x^i\partial x^k} - \frac{^*\partial^2}{\partial x^k\partial x^i} = \frac{2}{c^2}\,A_{ik}\frac{^*\partial}{\partial t}\,,$$

and also from the fact that the chr.inv.-metric tensor

$$h_{ik} = -\,g_{ik} + \frac{g_{0i}\,g_{0k}}{g_{00}} = -\,g_{ik} + \frac{1}{c^2}\,v_i\,v_k\,,$$

which is the chr.inv.-projection of the fundamental metric tensor $g_{\alpha\beta}$ onto the spatial section $h^\alpha_i h^\beta_k\,g_{\alpha\beta} = -\,h_{ik}$, may not be stationary. The main observable characteristics are the chr.inv.-vector of gravitational inertial force F_i, the chr.inv.-tensor of angular velocities of the space rotation A_{ik}, and the chr.inv.-tensor of rates of the space deformations D_{ik}, namely

$$F_i = \frac{1}{\sqrt{g_{00}}}\left(\frac{\partial\mathrm{w}}{\partial x^i} - \frac{\partial v_i}{\partial t}\right),$$

$$A_{ik} = \frac{1}{2}\left(\frac{\partial v_k}{\partial x^i} - \frac{\partial v_i}{\partial x^k}\right) + \frac{1}{2c^2}\left(F_i v_k - F_k v_i\right),$$

$$D_{ik} = \frac{1}{2}\frac{^*\partial h_{ik}}{\partial t}\,, \quad D^{ik} = -\frac{1}{2}\frac{^*\partial h^{ik}}{\partial t}\,, \quad D = D^k_k = \frac{^*\partial \ln\sqrt{h}}{\partial t}\,,$$

where w is the gravitational potential

$$\mathrm{w} = c^2\left(1 - \sqrt{g_{00}}\right),$$

and v_i is the linear velocity of the space rotation

$$v_i = -\,c\,\frac{g_{0i}}{\sqrt{g_{00}}}\,, \quad v^i = -\,c\,g^{0i}\sqrt{g_{00}}\,, \quad v_i = h_{ik}v^k,$$

while $h = \det\|h_{ik}\|$, $hg_{00} = -g$, $g = \det\|g_{\alpha\beta}\|$. Observable inhomogeneity of the space is set up by the chr.inv.-Christoffel symbols

$$\Delta^i_{jk} = h^{im}\Delta_{jk,m} = \frac{1}{2}\,h^{im}\left(\frac{^*\partial h_{jm}}{\partial x^k} + \frac{^*\partial h_{km}}{\partial x^j} - \frac{^*\partial h_{jk}}{\partial x^m}\right),$$

which are built just like Christoffel's usual symbols

$$\Gamma^\alpha_{\mu\nu} = g^{\alpha\sigma}\,\Gamma_{\mu\nu,\sigma} = \frac{1}{2}\,g^{\alpha\sigma}\left(\frac{\partial g_{\mu\sigma}}{\partial x^\nu} + \frac{\partial g_{\nu\sigma}}{\partial x^\mu} - \frac{\partial g_{\mu\nu}}{\partial x^\sigma}\right)$$

using h_{ik} instead of $g_{\alpha\beta}$. Components of the usual Christoffel symbols are linked to the chr.inv.-Christoffel symbols and other chr.inv.-chractersitics of the accompanying reference space of the given observer by the relations

$$D^i_k + A^{\cdot i}_{k\cdot} = \frac{c}{\sqrt{g_{00}}}\left(\Gamma^i_{0k} - \frac{g_{0k}\Gamma^i_{00}}{g_{00}}\right),$$

$$F^k = -\frac{c^2\,\Gamma^k_{00}}{g_{00}}\,, \qquad g^{i\alpha}g^{k\beta}\,\Gamma^m_{\alpha\beta} = h^{iq}h^{ks}\Delta^m_{qs}\,.$$

Zelmanov had also found that the chr.inv.-quantities F_i and A_{ik} are linked to one another by two identities

$$\frac{^*\partial A_{ik}}{\partial t} + \frac{1}{2}\left(\frac{^*\partial F_k}{\partial x^i} - \frac{^*\partial F_i}{\partial x^k}\right) = 0\,,$$

$$\frac{^*\partial A_{km}}{\partial x^i} + \frac{^*\partial A_{mi}}{\partial x^k} + \frac{^*\partial A_{ik}}{\partial x^m} + \frac{1}{2}\left(F_i A_{km} + F_k A_{mi} + F_m A_{ik}\right) = 0$$

which are known as *Zelmanov's identities*.

Zelmanov deduced chr.inv.-formulae for the space curvature. He followed that procedure by which the Riemann-Christoffel tensor was built: proceeding from the non-commutativity of the second derivatives of an arbitrary vector

$$^*\nabla_i{}^*\nabla_k Q_l - {}^*\nabla_k{}^*\nabla_i Q_l = \frac{2A_{ik}}{c^2}\frac{^*\partial Q_l}{\partial t} + H_{lki\cdot}^{\cdots j}\, Q_j\,,$$

he obtained the chr.inv.-tensor

$$H_{lki\cdot}^{\cdots j} = \frac{^*\partial \Delta_{il}^j}{\partial x^k} - \frac{^*\partial \Delta_{kl}^j}{\partial x^i} + \Delta_{il}^m\,\Delta_{km}^j - \Delta_{kl}^m\,\Delta_{im}^j$$

which is similar to Schouten's tensor from the theory of non-holonomic manifolds. The tensor $H_{lki}^{\cdots j}$ differs algebraically from the Riemann-Christoffel tensor because of the presence of the space rotation A_{ik} in the formula. Nevertheless its generalization gives the chr.inv.-tensor

$$C_{lkij} = \frac{1}{4}\left(H_{lkij} - H_{jkil} + H_{klji} - H_{iljk}\right),$$

which possesses all the algebraic properties of the Riemann-Christoffel tensor in this three-dimensional space and, at the same time, the property of chronometric invariance. Therefore Zelmanov called C_{iklj} the *chr.inv.-curvature tensor* the tensor of the observable curvature of the observer's spatial section. Its successive contraction

$$C_{kj} = C_{kij\cdot}^{\cdots i} = h^{im}C_{kimj}\,, \qquad C = C_j^j = h^{lj}C_{lj}$$

gives the chr.inv.-scalar C, which is the *observable three-dimensional curvature* of this space.

Chr.inv.-projections of the Riemann-Christoffel tensor

$$X^{ik} = -c^2\frac{R_{0\cdot0\cdot}^{\cdot i\cdot k}}{g_{00}}\,, \quad Y^{ijk} = -c\,\frac{R_{0\cdots}^{\cdot ijk}}{\sqrt{g_{00}}}\,, \quad Z^{ijkl} = c^2R^{ijkl},$$

after substituting the necessary components of the Riemann-Christoffel tensor and lowering indices, are

$$X_{ij} = \frac{^*\partial D_{ij}}{\partial t} - \left(D_i^l + A_{i\cdot}^{\cdot l}\right)\left(D_{jl} + A_{jl}\right) + \frac{1}{2}\left(^*\nabla_i F_j + {}^*\nabla_j F_i\right) - \frac{1}{c^2}F_iF_j\,,$$

$$Y_{ijk} = {}^*\nabla_i\left(D_{jk} + A_{jk}\right) - {}^*\nabla_j\left(D_{ik} + A_{ik}\right) + \frac{2}{c^2}A_{ij}F_k\,,$$

$$Z_{iklj} = D_{ik}D_{lj} - D_{il}D_{kj} + A_{ik}A_{lj} - A_{il}A_{kj} + 2A_{ij}A_{kl} - c^2C_{iklj}\,,$$

where we have $Y_{(ijk)} = Y_{ijk} + Y_{jki} + Y_{kij} = 0$, just like the Riemann-Christoffel tensor. Successive contraction of the spatial observable projection Z_{iklj} gives

$$Z_{il} = D_{ik}D_l^k - D_{il}D + A_{ik}A_{l\cdot}^{\cdot k} + 2A_{ik}A_{\cdot l}^{k\cdot} - c^2C_{il}\,,$$

$$Z = h^{il}Z_{il} = D_{ik}D^{ik} - D^2 - A_{ik}A^{ik} - c^2C\,.$$

Accordingly, Einstein's equations in the case where matter is arbitrarily distributed throughout the space have the chr.inv.-projections (the chr.inv.-Einstein equations)

$$\frac{^*\partial D}{\partial t} + D_{jl}D^{jl} + A_{jl}A^{lj} + \left(^*\nabla_j - \frac{1}{c^2}F_j\right)F^j = -\frac{\kappa}{2}\left(\rho c^2 + U\right) + \lambda c^2,$$

$$^*\nabla_j\left(h^{ij}D - D^{ij} - A^{ij}\right) + \frac{2}{c^2}F_j A^{ij} = \kappa J^i,$$

$$\frac{^*\partial D_{ik}}{\partial t} - \left(D_{ij} + A_{ij}\right)\left(D_k^j + A_{k\cdot}^{\cdot j}\right) + DD_{ik} + 3A_{ij}A_{k\cdot}^{\cdot j} - \frac{1}{c^2}F_iF_k +$$

$$+ \frac{1}{2}\left(^*\nabla_i F_k + {}^*\nabla_k F_i\right) - c^2C_{ik} = \frac{\kappa}{2}\left(\rho c^2 h_{ik} + 2U_{ik} - Uh_{ik}\right) + \lambda c^2 h_{ik}\,.$$

where $^*\nabla_j$ denotes the chr.inv.-derivative, for instance

$$^*\nabla_i\, q_k = \frac{^*\partial q_k}{dx^i} - \Delta_{ik}^l q_l\,, \quad {}^*\nabla_i\, q^k = \frac{^*\partial q^k}{dx^i} + \Delta_{il}^k q^l,$$

$$^*\nabla_i\, q_{jk} = \frac{^*\partial q_{jk}}{dx^i} - \Delta_{ij}^l q_{lk} - \Delta_{ik}^l q_{jl}\,,$$

$$^*\nabla_i\, q_j^k = \frac{^*\partial q_j^k}{dx^i} - \Delta_{ij}^l q_l^k + \Delta_{il}^k q_j^l\,,$$

$$^*\nabla_i\, q^{jk} = \frac{^*\partial q^{jk}}{dx^i} + \Delta_{il}^j q^{lk} + \Delta_{il}^k q^{jl},$$

$$^*\nabla_i\, q^i = \frac{^*\partial q^i}{\partial x^i} + \Delta_{ji}^j q^i = \frac{^*\partial q^i}{\partial x^i} + \frac{^*\partial \ln\sqrt{h}}{\partial x^i}\, q^i,$$

$$^*\nabla_i\, q^{ji} = \frac{^*\partial q^{ji}}{\partial x^i} + \Delta_{il}^j q^{il} + \frac{^*\partial \ln\sqrt{h}}{\partial x^i}\, q^{ji},$$

while the quantities

$$\rho = \frac{T_{00}}{g_{00}}\,, \qquad J^i = \frac{cT_0^i}{\sqrt{g_{00}}}\,, \qquad U^{ik} = c^2T^{ik}$$

(from which we have $U = h^{ik}U_{ik}$) are the chr.inv.-components of the energy-momentum tensor $T_{\alpha\beta}$ of distributed matter: the physical observable density of the field energy ρ, the physical observable density of the field momentum vector J^i, and the physical observable stress-tensor U^{ik}. For instance, the energy-momentum tensor of the electromagnetic field has the form [20]

$$T_{\alpha\beta} = \frac{1}{4\pi}\left(-F_{\alpha\sigma}F_{\beta\cdot}^{\cdot\sigma} + \frac{1}{4}\,F_{\mu\nu}F^{\mu\nu}g_{\alpha\beta}\right),$$

where $F_{\alpha\beta}$ is the electromagnetic field tensor (so-called Maxwell's tensor). (It follows that the field density ρ is connected to the quantity $U = h^{ik}U_{ik}$ by $\rho c^2 = U$.)

In this way, for any quantity or equation obtained using general covariant methods, we can calculate their physically observable projections on the time line and the spatial section of any particular reference body and formulate the projections in terms of their real physically observable properties, from which we obtain equations containing only quantities measurable in practice.

LETTERS TO PROGRESS IN PHYSICS

Comment on the "Declaration of the Academic Freedom" by D. Rabounski

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At least four major misconceptions gravely affect science and technology today, and the progress of scientific and technological research. These misconceptions are related to a utilitarian view of science, whereby large-scale collaborations and institutions of higher learning are conceived of as the only means for developing science and technology, where scientific publication is the sole aim of scientific research, within a commercial view of the nature of these human endeavours and activities. It is revealed herein just how abusive and destructive these misconceptions are, and to what great extent they now plague society. In complementing D. Rabounski's recent Declaration of the Academic Freedom, scientific and technological research should reaffirm its free, universal and critical nature, as a source of human dignity and honour, honesty and lucidity. Unfortunately, a despicable vulgarization of science and technology has led nowadays to a widely held relativism and uncertainty, which is employed as a theoretical ideology for manipulation and domination, placing human society in great peril.

Science and technology has changed human life essentially and irreversibly, both personal and social, the environment, and created a new, artificial world with profound cultural implications at the level of human behaviour, psychology and mentality. Human society today depends essentially on science and technology, to the point that life on Earth can be irreversibly damaged by the loss of science and technology. The only thing today that still remains outside the scope of science and technology is the creation of life, although basic modification of life is already present, and destroying life by science and technology is routine. Today's science and technology teaches us that the planet Earth, the Solar System, and perhaps the whole Universe, are very likely casual, and perhaps not eternal. It is therefore much more sensible to do everything possible to preserve life, for as long as possible.

Science and technology are now in great peril, not only due to social and political changes, and not only by a very uncontrollable economic activity, but also by various misconceptions. The latter are the most pernicious, because the human world is indeed a "matter of will and representation" (Schopenhauer). There are at least four plagues which the vulgarization of science and technology have generated in our modern society: relativism, indeterminacy, utilitarianism, manipulation and domination, and which now collectively turn against science and technology.

I adduce herein a series of current injurious misconceptions related to science and technology.

It is wrong, but widely held today, that science must satisfy any immediate desire or need, either physical or mental, as whimsical as may be, and that technology must satisfy as soon and most economically as possible. This is profoundly wrong. Science responds only to our intellectual impulse, this is its nature, to "accommodate in the most economical way our sensations to our ideas, which is a basic need for our survival" (Planck). It is indeed a deep wonder, which nobody could have ever explained, and probably cannot ever, that answering our intellectual questions may sometimes result in practical, technological applications that make our life more comfortable. History shows this, without explanation, but it also definitely shows that the way from science to technology is not direct, but a very mediated one. To bring scientific discoveries into practical life one needs commitment, investment, patience, competence, a lot of work, and, especially, the acceptance of the possibility that it may never happen at all. Science teaches us basically that its technological applications are in fact a matter of good luck, and we must accept this point as a scientific statement, as strange as it may sound. It reveals the autonomy and the freedom of science, which bears upon its profound nature. The politicians and policy-makers of today must accept that it is not they who should direct science and technology, but instead precisely the opposite, it is science and technology which should direct them, if life is going to be preserved and cultivated. Admittedly, it is difficult to accept that science would not be "scientific". Actually, as a matter of fact, science is nothing else but that endeavour that makes human the mysteries of the natural world, as the history of Mankind testifies.

Another common misconception about science nowadays is that science must be done exclusively in collaboration, and, as such, the broader the collaboration, the better — it is the only possible way to achieve scientific advances.

This is wrong. First, history proves the contrary. Newton worked alone, Maxwell similarly, Boltzmann worked alone and much against the current wisdom, Einstein likewise notoriously, the quantum physicists in the first half of the 20th century worked in a restricted cooperation, etc, etc. Feynman used to talk a lot with people around and about, find problems and work them for himself, alone. There is no other way. Similar examples occur in sciences other than physics. No profound scientific discovery has ever been made by many people, but always by one or, occasionally, by a few at any time. This is not only a historical fact, but a logical one too. If a discovery emerged in the heads of many, then it would not be something new, nor revolutionary, but instead, it would be a routine, trivial thing, by definition. Another, positive argument, without resorting to the *demonstratio per absurdum*, is the following. Suppose that for one scientific problem there would be many, most valuable contributors. Since the problem is one and these contributors are many it follows that each of them brings only a small contribution. Then, the problem is never solved by any one of them, but by one, who synthesized the work of the many. That does not mean that many workers in science or technology are not desirable, or that they would be superfluous. On the contrary, they make a valuable research environment, their work is the fuel of great discoveries, but it is only the coal in the scientific furnace. It is not science, it is only the probable way toward science. Science is what a few do based on the work of many. As such, the opinion of the many in science is useless, and always dangerous, because they do not know. They are non-scientific, they are only the material used in scientific and technological discoveries. Democracy in science and technology is a most dangerous thing, because it is contrary to the scientific spirit and to the nature of these endeavours. In contrast with political and social life, where today democracy is the accepted way of making mistakes, in science and technology the only acceptable medium of making mistakes along the way to the correct answer is the scientific and technical aristocracy. Only the latter "knows what knows and what does not know" (Socrates), which is its claim to competence. The former, people at large, do not know what knows, or what they don't. In its endeavour to acquire positive knowledge, *i.e.* that knowledge which is so probable to be taken as granted and warranted, science must only use lucidity and honesty, and cannot afford any inconsequential talk. This points again towards a basic feature of science and technology, that of creativity, which comes from their profound freedom and autonomy, a sense of honour generated exclusively by honesty and lucidity. Our attention nowadays is insistently and ideologically forced, by politics and the media, towards great scientific and technological organizations, as the only way of developing science and technology. This is a dishonest enterprise, the content of such actions is anti-scientific. Such people say one thing but mean the opposite. They abuse science, falsify and manipulate it, for image and political ends. Science and technology can only be achieved in an adequate environment, and the institutions of research of today are more than welcome, the larger the better. But we must be aware that they are there only for the purpose of an act of scientific or technological discovery, and not for becoming ends in themselves. Scientists must not, by necessity, belong to any such large organizations, in order to be scientists, or engineers. The requirement of an institutional enrollment for scientists and engineers is an abusive plague upon our mentality nowadays, with profound negative consequences. Today, scientific work can be carried out by electronic means as an individual, building upon the work of smaller or larger scientific and technical organizations. The factual reality shows that any discovery in science and technology was made by individuals, who used the work of many, sometimes of hordes. The big organizations of scientific research and technology are necessary, but not sufficient, by no means. They are just disposable means. Since the means should not dictate our aims, democracy must not be permitted to decide upon scientific and technological matters. It must be fully and for ever banished from science and technology. In science and technology we do not know the solutions. But certainly the "solutions" of the many are wrong, especially because they do not know what they do not know. This is why the opinion of those who "know that they do not know" is by far preferable, and history proves this point. In political and social life democracy may be a convenient instrument, especially when and where the majority is meager. Then, we have a permanent civil war in society, without a very definite outcome, which gains time for social life.

Another misconception which produces much damage to scientific research is related to scientific publications. Scientific publications are a means of doing scientific research, and they do occur naturally in the process of research. They are meant to present results of scientific research to the scientific public, in order to help science advance. The aim of scientific research is to get scientific results, which naturally are materialized in scientific publications. If we define, as is the case today, that scientific publications are the aim and the goal of scientific research, we confound the means for the aim, thereby falsifying scientific research and impeding the progress of science. Scientific authors of today no longer publish for a scientific aim, they publish instead only for the number of "papers". The great pressure of "publish or perish" placed today upon scientific researchers by various political and administrative bodies, by the research institutional organizations and universities, has definitely turned the attention of the researchers from science to publications. The scientific literature has been invaded by an enormous amount of publications, at a tremendously increasing rate, which contains no scientific result, which nobody reads, and which is completely useless. Such publications are merely "progress reports", which mean only that "time has passed" (Oppenheimer), and reveal only that the research funds have been spent. They have been spent indeed, but not on research. They have been spent on useless publications, and the costs obviously do not match the output. The requirement of publications as an end *per se* is one of the greatest attacks the political and administrative media are now mounting against scientific research, its freedom, liberty, and its very nature. It has deliberately misled contemporary scientific research along a false path, and locked genuine scientific individuals outside the social organization of scientific research. Mankind is losing and wasting one of its most valuable natural resources, scientific creativity. Moreover, influential political and administrative bodies and organizations with a commercial orientation have defined a number of scientific journals as the "main stream", according to their rate of citations, in the "impact factor", in complete disregard for their scientific contents. Research which is not in this "main stream" perishes, it is not funded, whilst those which belong to such influential organizations are published, funded and run forever, without any scientific result: producing only with a massive literature, good for nothing. Because the frequent citation of such literature is improper, there is no reference to the scientific content, which is absent, because it is just a formality, a ritual of the publications industry. The "impact factor" is defined by these organizations as the ratio of the number of citations to the number of published papers, so the scientific journals of today publish only those papers which are most likely to be cited, *i.e.* those which come precisely from the same influential organizations which define the impact factor. This is a self-approving type of institutional activity, which is closed in itself, permits no criticism, no contrary opinion, and, as such, is typical of underground, criminal, terrorist-like, dictatorial, secret societies and organizations. In fact, the secret character of these organizations is obvious in their practice of the "anonymous peer review" procedure. These "main stream" journals have in fact a quite notorious and ignominious past: they have rejected from publication authors like Einstein, Schwinger, Fermi and also Feynman. Many articles published today by the foremost "main stream" scientific journals are withdrawn soon thereafter by the authors, which reflects conflict within those organizations, very similar to the fights and wars between rival criminal mobs. Moreover, if the "impact factor" was instead referred to the number of papers in the sold copies according to declared users, we would have a very different picture, and the "main stream" would be seen immediately to be in fact a "mean stream", because there are a lot of declared-users sold copies of these journals which nobody reads. Research funds are spent not only to produce such journals, but to buy them, without being read or used. This is a vicious activity which falsifies scientific research, and to impose the "main stream" upon scientific activity is another great attack upon the freedom of scientific research. To exclude from publication people who do not belong to those influential organizations is an attack upon the universality of science. In 1920 Sommerfeld established a new scientific journal, which soon became the famous Zeitschrift für Physik. This journal never had reviewers, let alone "anonymous reviewers". The scientific articles were published under the sole scientific and moral authority of Sommerfeld. This real freedom permitted the birth of quantum mechanics, nuclear and solid-state physics and all the other branches of modern Physics. Of course, not all of the papers published in Zeit Phys were good, and Sommerfeld did not understand them all. But he was a professional of science, and where his professional expertise could not help him, he exercised his honesty and lucidity. This is competence in science.

Another misconception regarding the scientific research of today is that it must be self sustaining, as any commercial activity. This is a nonsense. The nature of scientific "products", which are the scientific results, is such that not only does nobody buy them, but they are also offered freely. These "products" have no immediate practical utility. The best we can expect is to bring them to the attention of as many learned people as possible, and even to society at large, in order to get new ideas, visions, perspectives, etc., and to make apparent possible practical applications. The latter depend on technological skills and means, which is an undertaking in its own right. It does not only make use of the scientific results, but it provides scientific research with new suggestions and ideas. As such, both scientific research and technological development, which aims at practical applications of the scientific results, must be funded by society with no regard to immediate commercial reward. In comparison with other social costs, and in regard to its enormous benefits, as proved by history, the funding of scientific and technological research is modest; the highest spending today on science and technology does not exceed about 3–4% of GDP in the most developed countries. Scientific and technological research is funded today by government or corporations, by universities and private companies, and to a much less extent by sponsors, benefactors, philanthropists or a sort of "mecena". In all of these situations the misconceptions described above prevail and dominate, mixed up with a misleading financial "reasoning". First, the notion of "project funding" tends to be generalized up to the point that researchers get their salaries exclusively on an "competition" basis. This is nonsense: one cannot expect honest work from a worker who is not paid a regular salary. Consequently, "project competition" generates corruption, it is "lobby and lottery", it provides only an occasional, temporary and irregular income. Scientific researchers turn their attention from their real work to the process of getting funded through such a "competition" basis. "Project funding" was originally restricted to temporary jobs for PhD students or post-doctoral researchers, until these beginners secured a stable research, teaching, or technical position, and was mainly limited to universities as a form of further education and instruction, facilitating social insertion. Today, this "competition of project funding" tends to be generalized, destroying scientific research and scientific education. Indeed, it is almost universally accepted today that university professors should no longer concentrate upon their teaching mission, but should instead do research. This is a grave diversion, which explains why scientific education has degraded and declined so much in our modern society. As for research funding from sponsors or other individuals, this is a naive conception. Almost nobody gives personal money without asking for something rewarding in return. Scientific results produce satisfaction only when one takes part in getting them. Otherwise, such sorts of things are absurd. According to an old joke, "I love work. I would sit and watch it for hours". Such sponsors, benefactors, philanthropists and various "mecena", desire in fact publicity and image for their money to use these for getting in turn even more money. But image and publicity gained by scientific research means diverting the latter from its nature, and, in fact, abusing it. This is another grave injury inflicted upon scientific research by our modern society. A man who relatively recently invested $50,000.00 in a private research institute, took twice as much from government and public funds, and acquired 3 or 4 permanent staff. The institute now accommodates many visitors, whose expenses are paid by their respective institutional employers, and who deliver public lectures on nonsense such as black holes, the Big Bang, conscience, etc., etc. This is nice, to "scientize" the public at large, but it is pseudo-science. In addition, that fellow became an influential member of various government and academic bodies, from which he draws a big salary, which overcompensates by far the original $50,000.00, for his vulgarization of scientific research and his "great service" to society. Such are the methods of modern society for destroying science.

Funding scientific and technological research without asking for an immediate revenue, according to the nature of these activities, does not mean that these activities are unaccountable. On the contrary. But first let us remark that their products are not physical, but intellectual. As such, the printed paper, or the electronic archives, which embody the present scientific literature cannot be mistaken for the scientific results. Not even the experimental setups or apparatus produced by technological research should be mistaken for the result of this research, because they only serve to represent physically an idea. Scientific and technological research is accountable by its scientific and technical results, which are essentially spiritual, or intellectual, objects. This accountability is realized by the scientists themselves, who are able to speak clearly, logically and, especially, critically about their own work. The democratic vote of the majority is nonsense in this enterprise. (I have witnessed, at a degraded nuclear laboratory, the neutron lifetime established by majority vote; they decided about 1 second.) The responsible political, administrative and social elements are afraid of being trumped by scientists in this process of accountability. I can assure them that they wouldn't. But of course, these people must try to become a little literate in science and technology. And finally, what is not risky today in any enterprise? A sure and safe business either does not exist or it is illegal. The fact that we do not know does not give us the right to abuse and destroy scientific research, nor to falsify it. The latter is illegal, and deserves legal punishment, the former is bad and irreversibly damaging for us, for our children and for the whole future of Mankind. It is morally culpable.

The Declaration of Academic Freedom, or Scientific Freedom, is quite welcome, and essentially declares the following Rights.

According to its nature, scientific research has the Right of doing Science; it has the Right of doing it in perfect Freedom and Universality, aiming exclusively at spiritual and intellectual results, without interference from political, administrative or social organizations, to publish its scientific results wherever, whenever and in whatever way it considers appropriate. It has the Right of discussing openly, freely and critically, whatever the result declared as being scientific, and society must warrant this Right and facilitate its exercise. It has the Right of being funded appropriately by society and the Right of accounting for its own results according to its own criteria, ways, methods and procedures. Scientific and technological research has the Right of dismissing as abusive, intruding and falsifying, the use of democracy in scientific matters, the "main stream" publications and "impact factor" as means of evaluation, "project competition" as a means of funding. It has the Right of being Free and Autonomous, and to give account of its results to the whole of society, according to its own methods, practices, procedures, historically established. The Right to Scientific Research is a Fundamental Human Right.

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LETTERS TO PROGRESS IN PHYSICS

Is Classical Statistical Mechanics Self-Consistent?

(A paper in honour of C. F. von Weizsäcker, 1912–2007)

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In addition to his outstanding achievements in physics and activities in policy, C.-F. von Weizsäcker is famous for his talks, given as a member of the Academy Leopoldina. Due to the latter, I could learn quite a lot from his methodological writings. In particular, he is the only modern thinker I'm aware of who has pointed to the difference between Newton's and Laplace's notions of state. But this difference is essential for the relationship between classical and quantum physics. Moreover it is the clue to overcoming Gibbs' paradox within classical statistical mechanics itself.

1 Introduction

With Carl-Friedrich Freiherr von Weizsäcker (1912–2007) an outstanding physicist, philosopher and human being passed away. Born into a family with long traditions of widespread interests, activities and education — his father was a highly ranked diplomat, his younger brother Richard was President of Western Germany — he showed from the very beginning a strong interest in both physics and philosophy. His talks as a member of the German Academy of Sciences Leopoldina are famous not only by their original content, but also by his humour. His books on methodological and historical issues display his broad scope, and are full of wise insights. As a master, he acknowledged the masters of the past; one can learn from him how to learn from the masters, then and now. Notably, I remember his reference to Euler's (1707–1783) reasoning on the equivalence of causal (differential equations) and teleological descriptions (minimum principles), and his pointing to the difference between the notions of state as used by Newton (1643–1727), and today, respectively [1]. As the latter has profound implications even for modern physics, I would like to honour von Weizsäcker through outlining its relevance for statistical and quantum physics.

2 State and motion

2.1 Conservation laws vs laws of motion

Descartes (1596–1650), Huygens (1629–1695), Newton and Euler started their exposition of the basic laws with the conservation of (stationary) state. This is followed by the change of state and eventually by the change of location (equation of motion). The location of a body is not a state variable, because it changes even without the action of an external force, i.e., without reason. The latter kind of reasoning was abandoned at the end of 18th century as part of scholastics ([1], p. 235). The centre of the Lagrange (1736–1813) formalism is occupied by the Lagrangian equation of motion, i.e., equations for the non-state variable location (represented by the generalized coordinates).

On the other hand, this equation of motion indicates at once the conservation of (generalized) momentum for the force-free motion of a body in a homogeneous space. Indeed, there is a very tight interconnection of symmetries and conserved quantities in general, as stated in Noether's (1882–1935) theorem, the mechanical and field-theoretical applications of which being usually expressed by means of the Lagrange formalism. The principle of least action containing the Lagrange function is often even placed at the pinnacle of mechanics.

This development has strengthened the focus of physicists on the equations of motion and weakened their attention on the laws of state conservation, despite the extraordinary rôle of energy in quantum mechanics and Bohr's (1885–1962) emphasis on the fundamental rôle of the principles of state conservation and of state change [2]. Indeed, there are derivations of Newton's equation of motion from the energy law, e.g., in [3, 4, 5]; a deduction of Hamilton's (1805–1865) equation of motion from Euler's principles of classical mechanics can be found in [6, 7].

Thus, there are two traditional lines of thought,

- the "physics of conserved quantities": Parmenides (ca. 515 BC — ca. 445 BC) — Descartes — Leibniz (1646–1716), and
- the "physics of laws of change": Heraclites (ca. 388 BC — ca. 315 BC) — Galileo (1564–1642) — Newton.

In the end, both lines are equivalent, leading eventually to the same results, as first shown by Daniel Bernoulli (1700–1782) [8].

2.2 Motion vs stationary states

In classical mechanics, if an external force ceases to act upon a body or conservative system, the latter remains in that stationary state it has assumed at that moment. Non-stationary motion is a continuous sequence of stationary states. Consequently, the set of stationary states of a system determines both its stationary and its non-stationary motions and, in particular, its set of possible configurations. For instance, the turning points of a pendulum are determined by its energy.

In quantum mechanics, the situation is somewhat more complicated. The set of stationary states is (quasi-)discontinuous. The external influence vanishes most likely at an instant, when the wave function of the system is *not* equal to one of the stationary states. However, it can be constructed from the stationary wave functions. According to Schrödinger (1887–1961) [9], the transition between two states is characterized by contributions to the wave function from both states. It's like climbing a staircase without jumping, i.e., the one foot leaves the lower step only after the other foot has reached the higher step. In this sense, the fashionable term "quantum leap" is a fiction. Therefore, the quantum motion, too, is largely determined by the stationary states.

2.3 State variables vs quantum numbers

A freely moving body exhibits 3 Newtonian state variables (e.g., the 3 components of its momentum vector; c.f. Laws 1 and 2), but 6 Laplacian state variables (e.g., the 6 components of its velocity and position vectors; c.f. Laplace's demon [10]). A freely moving spinless quantum particle exhibits 3 quantum numbers (e.g., the 3 components of its momentum vector).

The planets revolving around the sun à la Kepler (1571–1630) exhibit 3 Newtonian state variables (e.g., the total energy and 2 components of the angular momentum), but 6 Laplacian state variables (e.g., those of free bodies, given above). Neglecting spin, the one-electron states of atoms are labeled by 3 quantum numbers (1 for the energy plus 2 for the angular momentum). The same applies to the three-dimensional classical and quantum oscillators, respectively.

The example of these three basic systems of mechanics, both classical and quantum, clearly demonstrates that the Newtonian notion of state — corresponding largely to the modern notion of stationary states — is much more appropriate for comparing classical and quantum systems than the Laplacian notion of state. It should be enlightening to draw these parallels for field theory.

3 (In)Distinguishability

3.1 Permutation symmetry of Newtonian state functions

Two classical bodies are equal if they possess the same mass, size, charge, etc. [11]. A simple example is given by the red balls of snooker (a kind of billiards; I abstract, of course, from deviations caused by the production process). Due to the unique locus of a body, they can be distinguished by their locations and, thus, are not identical. For the outcome of a snooker game, however, this does not play any rôle. Similarly, for recognizing a player of the own team, only the color of the tricot is important, not its size. In other words, it is not the totality of properties that matters, but just that subset which is important for the current situation.

The Hamilton function of a system of equal bodies is invariant under the interchange of two bodies (permutation of the space and momentum variables). More generally, given only the Newtonian state variables of a system, the classical (!) bodies in it are indistinguishable. This allows for discussing the issue of (in)distinguishability within classical dynamics. Equal quantum particles are also not identical, if they can be distinguished through their localization.

3.2 Distribution functions vs energy spectrum

In his 1907 paper "Planck's theory of radiation and the theory of specific heat of solids" [12], Einstein (1879–1955) not only founded the quantum theory of solids, but demonstrated also, that the differences between the classical and quantum occupation of states result from the different character of the energy spectra of classical and quantum systems, respectively; and he defined quantization as a selection problem [6, 7].

Wien's (1864–1928) classical distribution law he obtained by using the continuous energy spectrum of a classical oscillator, while Planck's (1858–1947) non-classical distribution law emerges from the discrete energy spectrum of a quantum oscillator.

In a perfect crystal, the atoms oscillate around localized lattice positions and, therefore, are distinguishable. Their interaction, however, leads to collective oscillations called normal modes. In these common states, the individual lattice atoms become indistinguishable. It is these normal modes that were actually used by Einstein. However, due to the use of Newton's notion of state Einstein was able to derive Planck's distribution law by means of "classical" arguments.

3.3 Gibbs' paradox

Consider a box filled uniformly with a gas in thermal equilibrium. When putting a slide sufficiently slowly into it, dividing the box into two parts, no macroscopic quantity of the box as a whole should change. However, within conventional classical statistical mechanics, the entropy changes drastically, because the interchange of two molecules from now different parts of the box is regarded as being significant. This is called Gibbs' (1839–1903) paradox [13]. In conventional representations, it is argued that, actually, the molecules are quantum particles and, thus, indistinguishable; the double counting is corrected ad hoc.

Now, as outlined above, if Newton's rather than Laplace's notion of state is used, an interchange of any two molecules of the same part or of different parts of the box, does not affect the state. Therefore, the artifact of Gibbs' paradox can be avoided from the very beginning when working with Newton's notion of state, as can be seen from Einstein's 1907 paper discussed above.

4 Summary and discussion

Contrary to Einstein's results, Ehrenfest (1880–1933) [14] and Natanson (1864–1937) [15] explained the difference between the classical and quantum radiation laws by means of different counting rules for distinguishable and indistinguishable particles ([16], §1.4; [17], vol. 1, pt. 2, sect. V.3). Apparently supported by the uncertainty relation, in particular, after its "iconization" as the "uncertainty principle", this view prevailed for most of the 20th century. Only at its end was it realized more and more that it is not the (in)distinguishability of particles that matters, but that of the states (e.g. [18], sects. 1 and 2.1; [19], sect. 4.1). Using Newton's rather than Laplace's notion of state, the statistical reasoning in [18, 19] can be physically-dynamically substantiated.

It needs, perhaps, a congenial mixing of physics and philosophy, like that of von Weizsäcker, to recognize and stress the importance of notions within physics. As the notions are the tools of our thinking, the latter cannot be more accurate than the former.

Both Newton's and Laplace's notions of state exhibit advantages [20]. The proper use of them makes classical statistical mechanics self-consistent.

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Carl Friedrich von Weizsäcker, 1983.

Biography*

Carl Friedrich Freiherr (Baron) von Weizsäcker (June 28, 1912, Kiel – April 28, 2007, Säcking near Starnberg) was a German physicist and philosopher. He was the longest-living member of the research team which tried, and failed, to develop a nuclear weapon in Germany during the Second World War.

Weizsäcker was born in Kiel, Germany, the son of the German diplomat Ernst von Weizsäcker. He was the elder brother of the former German President Richard von Weizsäcker, father of the physicist and environmental researcher Ernst Ulrich von Weizsäcker and father-in-law of the former General Secretary of the World Council of Churches Konrad Raiser.

From 1929 to 1933, Weizsäcker studied physics, mathematics and astronomy in Berlin, Göttingen and Leipzig supervised by and in cooperation, e.g., with Werner Heisenberg and Niels Bohr. The supervisor of his doctoral thesis was Friedrich Hund.

His special interest as a young researcher was the binding energy of atomic nuclei, and the nuclear processes in stars. Together with Hans Bethe he found a formula for the nuclear processing in stars, called the Bethe-Weizsäcker formula and the cyclic process of fusion in stars (Bethe-Weizsäcker process, published in 1937).

Note regarding personal names: *Freiherr* is a title, translated as *Baron*, not a first or middle name. (The female forms are *Freifrau* and *Freiin*.)

During the Second World War, he joined the German nuclear energy project, participating in efforts to construct an atomic bomb. As a protegee of Heisenberg, he was present at a crucial meeting at the Army Ordinance headquarters in Berlin on 17 September 1939, at which the German atomic weapons program was launched. In July 1940 he was co-author of a report to the Army on the possibility of "energy production" from refined uranium, and which also predicted the possibility of using plutonium for the same purpose. He was later based at Strasbourg, and it was the American capture of his laboratory and papers there in December 1944 that revealed to the Western Allies that the Germans had not come close to developing a nuclear weapon.

Historians have been divided as to whether Heisenberg and his team were sincerely trying to construct a nuclear weapon, or whether their failure reflected a desire not to succeed because they did not want the Nazi regime to have such a weapon. This latter view, largely based on postwar interviews with Heisenberg and Weizsäcker, was put forward by Robert Jungk in his 1957 book *Brighter Than a Thousand Suns*. Weizsäcker states himself that Heisenberg, Wirtz and he had a private agreement to study nuclear fission to the fullest possible in order to "decide" themselves how to proceed with its technical application. "There was no conspiracy, not even in our small three-men-circle, with certainty not to make the bomb. Just as little, there was no passion to make the bomb . . . " (cited from: C. F. von Weizsäcker, *letter to Mark Walker*, August 5, 1990).

The truth about this question was not revealed until 1993, when transcripts of secretly recorded conversations among ten top German physicists, including Heisenberg and Weizsäcker, detained at Farm Hall, near Cambridge in late 1945, were published. The *Farm Hall Transcript* revealed that Weizsäcker had taken the lead in arguing for an agreement among the scientists that they would claim that they had never wanted to develop a German nuclear weapon. This story, which they knew was untrue, was called among themselves *die Lesart* (the Version). Although the memorandum which the scientists drew up was drafted by Heisenberg, one of those present, Max von Laue, later wrote: "The leader in all these discussions was Weizsäcker. I did not hear any mention of any ethical point of view" (cited from: John Cornwell, *Hitler's Scientists*, Viking, 2003, p. 398). It was this version of events which was given to Jungk as the basis of his book.

Weizsäcker was allowed to return to Germany in 1946 and became director of a department for theoretical physics in the Max Planck Institut for Physics in Göttingen (successor of Kaiser Wilhelm Institut). From 1957 to 1969, Weizsäcker was professor of philosophy at the University of Hamburg. In 1957 he won the Max Planck medal. In 1970 he formulated a *Weltinnenpoltik* (world internal policy). From 1970 to 1980, he was head of the Max Planck Institute for the Research of Living Conditions in the Modern World, in Starnberg. He researched and published on the danger of nuclear war, what he saw as the conflict between the first world and the third world, and the consequences of environmental destruction. In the 1970's he founded, together with the Indian philosopher Pandit Gopi Krishna, a research foundation "for western sciences and eastern wisdom". After his retirement in 1980 he became a Christian pacifist, and intensified his work on the conceptual definition of quantum physics, particularly on the Copenhagen Interpretation.

His experiences in the Nazi era, and with his own behavior in this time, gave Weizsäcker an interest in questions on ethics and responsibility. He was one of the Gättinger 18 — 18 prominent German physicists — who protested in 1957 against the idea that the Bundeswehr should be armed with tactical nuclear weapons. He further suggested that West Germany should declare its definitive abdication of all kinds of nuclear weapons. However he never accepted his share of responsibility for the German scientific community's efforts to build a nuclear weapon for Nazi Germany, and continued to repeat the version of these events agreed on at Farm Hill. Some others believe this version to be a deliberate falsehood.

In 1963 Weizsäcker was awarded the Friedenspreis des Deutschen Buchhandels (peace award of the German booksellers). In 1989, he won the Templeton Prize for Progress in Religion. He also received the Order Pour le Mérite. There is a Gymnasium named after him, in the town of Barmstedt, which lies northwest of Hamburg, in Schleswig-Holstein, the Carl Friedrich von Weizsäcker Gymnasium im Barmstedt.

Main books by C. F. von Weizsäcker

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2. Die Geschichte der Natur. Göttingen, 1948.
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4. Wege in der Gefahr. München, 1976. Translated into English as The Politics of Peril, N.Y., 1978.
5. Der Garten des Menschlichen. München, 1977. Translated as The Ambivalence of Progress: Essays on Historical Anthropology, N.Y., 1988.
6. Introduction to The Biological Basis of Religion and Genius, by Gopi Krishna, N.Y., 1971, 1972 (the introduction takes half the book).
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LETTERS TO PROGRESS IN PHYSICS

Zelmanov's Anthropic Principle and Torah

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According to Jewish Kabbalistic tradition, nothing is real except for G-d. In this brief letter, originally addressed to Torah scholars, we demonstrate how Zelmanov's Anthropic Principle is consistent with this tradition by analyzing the famous question in philosophy, "If a tree falls in a forest and no one is around to hear it, does it make a sound?"

There is a famous question in philosophy: "If a tree falls in a forest and no one is around to hear it, does it make a sound?" Philosophers have been debating this question for centuries. The philosophers who answer "No", called idealists, are of the opinion that reality is whatever we perceive it to be. And the philosophers who answer "Yes', called realists, are of the opinion that reality exists independently of observers.

In the 1940's, the prominent cosmologist Abraham Zelmanov introduced his Anthropic Principle:

"The Universe has the interior we observe, because we observe the Universe in this way. It is impossible to divorce the Universe from the observer. The observable Universe depends on the observer and the observer depends on the Universe. If the contemporary physical conditions in the Universe change then the observer is changed. And vice versa, if the observer is changed then he will observe the world in another way. So the Universe he observes will be also changed. If no observers exist then the observable Universe as well does not exist" [1, 2].

The Anthropic Principle answer to the above question is both "Yes" and "No". "Yes", since the observer is dependent upon the observable Universe for his or her existence, so it is possible for sound, which is part of the observable Universe, to exist without an observer. And "No", since the observable Universe is dependent upon the observer for its existence, so it is impossible for sound to exist without an observer. So the Anthropic Principle seems to be logically contradictory. But Zelmanov's Anthropic Principle is nevertheless consistent with Torah. How is this possible?

According to our Torah sages of blessed memory, only G-d is real, since only G-d has an independent existence that is not subject to change from external factors.* The question, "If a tree falls in a forest and no one is around to hear it, does it make a sound?", is based upon the assumption that either the observer or the observable Universe is real. Thus according to the reasoning of our Torah sages of blessed memory, the question, "If a tree falls in a forest and no one is around to hear it, does it make a sound?", is based upon a false premise, since both the observer and the observable universe are not real (according to the sages' definition of "real"). Hence, it is possible for the answer to the question, "If a tree falls in a forest and no one is around to hear it, does it make a sound?" to be both "Yes" and "No" and still be consistent with Torah.

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*One of the best references for the claim that Torah tradition says that only G-d is real is the book entitled *Tanya*, by Rabbi Shneur Zalman of Liadi [3]. Book 2 of Tanya, entitled *Sha'ar ha-Yichud ve'ha'Emunah* (translated as *The Gateway of Unity and Belief*) explains this principle in detail.

Open Letter by the Editor-in-Chief: Declaration of Academic Freedom (Scientific Human Rights)
*The Bulgarian Translation**

Декларация за Академична Свобода

(Научни Човешки Права)

Клауза 1: Предисловие

Началото на 21-ви век отразява по-силно от всякога в историята на човечеството, дълбочината и значимостта на ролята, която науката и технологиите имат в човешките дела.

Мощното нахлуване на модерната наука и технологии в различни отрасли дава общоприетото впечатление, че бъдещи ключови открития са възможни принципно и единствено от големи правителствени или корпоративно финансирани изследователски групи, които имат достъп до изключително скъпа апаратура и орда от помощен персонал.

Това общоприето впечатление обаче е митично, и не отразява истинската природа на това как се правят научни открития. Големи и скъпи технологични проекти, без значение колко сложни, са всъщност резултат на приложението на проницателни научни прозрения на малка група от отдадени на науката изследователи или самостоятелни учени, често работещи в изолация. Учен, който работи сам, сега и в бъдеще, точно както и в миналото, ще може да прави открития, които значимо могат да повлияят на съдбата на човечеството и да променят лицето на цялата планета, която ние толкова незначително обитаваме.

Фундаментални открития по правило се правят от индивиди, които работят в подчинени позиции в правителствени агенции, изследователски и образователни институции, или комерсиални предприятия. Следователно изследователят често е подтискан от институционните или корпоративни директори, които работещи под друга агенда (дневен ред), се опитват да поемат контрол и да прилагат научните открития за лична или корпоративна изгода, или себевъзвеличаване.

Историята на научните открития е пълна със случаи на подтискане и подигравки към учения дързнал да се противопостави на установените догми, но в които през следващите години правотата на учения е била доказана чрез неумолимия марш на практическата необходимост и жаждата за интелектуално развитие. Също така историята е пълна и със случаи на мръсен и петнящ плагиаризъм и преднамерено фалшиво представяне на факти, престъпно извършено поради безскрупулност, мотивирана от завист и користолюбие. Така е и днес!

Целта на тази Декларация е да подкрепи и развие фундаменталната доктрина защитаваща, че научните изследвания трябва да са независими от скрито или открито подтискащо влияние от бюрократични, политически, религиозни или наказателни директиви, и че създаването на наука е човешко право не по-малко от други основни човешки права, които вече са разискани в различни международни спогодби и международни закони.

Всички учени с подобно мислене нека се придържат към тази Декларация в знак на солидарност с международната научна общност, и нека уважат правото на населението на Земята на неоковано от догми създаване на наука, всеки според собствените индивидуални възможности и предпочитания, за да може да се развива науката, и всеки, като порядъчен гражданин в този непорядъчен свят, да има шанс да допринесе максимална полза за човечеството.

Клауза 2: Кой е учен

Учен е всеки човек, който прави наука. Всеки човек, който сътрудничи с учен в развитието и представянето на идеи и данни в научните изследвания или прилагането им, е също учен. Наличието на професионална квалификация не е пререквизит за да може човек да бъде учен.

Клауза 3: Къде се прави наука

Научни изследвания могат да бъдат извършвани абсолютно навсякъде, например на работното място, в процес на образование, по време на спонсорирана академична програма, в научни групи, или самостоятелно вкъщи провеждайки собствено проучване.

Клауза 4: Свобода на избор на изследователска тема

Много учени работещи за високи научни звания или в други изследователски програми на научни институции като университети и институти за напреднали изследвания, биват възпрепятствани да работят по изследователска тема по собствен избор от висши академични и/или административни представители, не поради липса на необходимата техника, а поради това че академичната йерархия и/или други органи просто не одобряват проучва-

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нията, които могат да се противопоставят на общоприетата догма, любима теория, или поради финансирането на други проекти, които иначе биха могли да бъдат дискредитирани от предложеното проучване. Авторитетът на ортодоксалното мнозинство често бива използван за да потопи начинанията за дадено научно проучване, само и само за да не бъде разстроен бюджета. Тази общоприета практика на обмислено подтискане на свободната научна мисъл е ненаучна в своята екстремност, а освен това е и престъпна. Тя не може да бъде толерирана.

Учен работещ за някаква академична институция, власт или агенция, трябва да бъде абсолютно свободен да избира изследователска тема, ограничена само от материалната база и интелектуални възможности, които могат да бъдат предоставени от институцията, агенцията или властта. Ако учен провежда изследвания като част от сътрудническа група, ръководителите на проекта и водачите на група трябва да бъдат ограничени само до съвещателна и консултативна роля във връзка с избора на подходяща изследователска тема от учен в групата.

Клауза 5: Свобода на избор на изследователски методи

Често бива оказван натиск върху учения от административния персонал или по-старши академици във връзка с дадена изследователска програма провеждана в академична среда, за да се принуди учения да използва други методи от тези които той е избрал, без друга причина освен лични предпочитания, пристрастие, институционна политика, редакторска диктатура, или колективна власт. Тази практика, която е доста разпространена, е преднамерено отричане на свободата на мисълта и не може да бъде разрешена.

Некомерсиален или академичен учен има правото да развива изследователска тема по всеки рационален начин, който учения смята за най-ефективен. Финансовите решения относно това как ще се обезпечи изследването са собствен проблем на учения.

Ако некомерсиален или академичен учен работи като член на колаборативен некомерсиален или академичен колектив от учени, то лидерите на проекта и ръководителите на изследването трябва да имат само съвещателна или консултативна роля и не трябва да повлияват, променят или ограничават изследователските методи или изследователската тема на учен от групата.

Клауза 6: Свобода на участие и сътрудничество в научните изследвания

Налице е значим елемент на институционално съперничество в практиката на съвременната наука, съпътствано от елементи на лична завист или запазване на репутацията на всяка цена, независимо от научната действителност. Това често възпрепятства учените да отбелязват помощта на компетентни колеги от съперничещи институции или такива без академично работно място. Подобна практика също е преднамерено възпрепятстване на научния прогрес.

Ако некомерсиален учен иска помощ от друг човек, и този човек е съгласен, то ученият има свободата да покани този човек и да използва всякаква и цялостна помощ, при положение, че помощта е в рамките на предоставения изследователски бюджет. Ако помощта не зависи от предоставения бюджет, то учения има правото да наеме като асистент даден човек по собствена преценка, свободен от възпрепятстване от който и да е било.

Клауза 7: Свобода за несъгласие в научна дискусия

В резултат на скрита завист или направени капиталовложения, модерната наука ненавижда откритата научна дискусия и с желание забранява тези учени, които поставят под въпрос ортодоксалните възгледи. Много често учени с доказани качества, които показват проблеми в общоприета теория или интерпретация на данни, биват наричани ненормални, за да могат техните възгледи да бъдат игнорирани. Те биват подложени на присмех публично или в частна кореспонденция, систематично не биват допускани за участие в научни конгреси, семинари или колоквиуми, за да не могат техните идеи да имат слушатели. Преднамерена фалшификация на данни или изопачаване на дадена теория, сега са често оръжие в арсенала на тези които безскруполно целят подтискането на определени научни или исторически факти. Формирани международни комитети съставени от научни мерзавци сега провеждат и оглавяват научни конгреси на които могат да участват само последователи, които представят статии без значение от качеството на съдържанието им. Тези комитети използват крупни суми от обществения бюджет за да спонсорират собствените си проекти употребявайки измама и лъжи. Всяко възражение към техните предложения, което е базирано на научни аргументи бива заглушавано с всички налични средства, за да могат парите да продължават да текат в собствените научноизследователски сметки, по този начин гарантирайки им добре платено собствено работно място. По тяхна повеля част от противопоставилите се учени биват изхвърляни от работното място, други биват възпрепятствани от успешно уговаряне на научни мероприятия чрез изградена мрежа от корумпирани съучастници. В някои ситуации учени биват изхвърляни от конкурси за висши образователни програми, например докторантури, за това че са изразили идеи които подкопават дадена модна теория, независимо от това колко е отдавнашна тази ортодоксална теория. Фундаментален факт е, че никоя научна теория е непоклатима или неприкосновена, следователно всяка теория е отворена за дискусия и повторно оценяване. Това обаче е забравено от споменатите международни комитети. Те също така игнорират факта, че даден феномен може да има множество правдоподобни обяснения, и злостно дискредитират всяко обяснение което не е в унисон с тяхното ортодоксално мнение като без да се колебаят използват ненаучни аргументи за да оправдаят пристрастните си убеждения.

Всички учени трябва да бъдат свободни да обсъждат собствените си изследвания както и изследванията на други учени без страх от публично или лично безпричинно осмиване, без страх от това да бъдат обвинени, очернени, поставени под съмнение, или да бъдат дискредитирани по друг начин от безпочвени твърдения. Никой учен не бива да бъде поставян в положение в което прехраната или репутацията му да бъдат рискувани само заради изказването на научно мнение. Свободата за научно изразяване трябва да е първостепенна. Употребата на власт за отхвърлянето на научен аргумент е ненаучна и не трябва да бъде използвана за заблуда, потискане, заплашване, отлъчване от обществото, или по друг начин насилва или окована учения. Преднамереното потискане на научните факти или аргументи, както чрез действие така и чрез бездействие, а също и преднамереното подправяне на фактите за да подкрепят аргумент или дискредитират противопоставящ се възглед, е научна измама, която е равна на научно престъпление. Принципите на доказване трябва да водят всяка научна дискусия, независимо дали доказателтсвото е физично, теоретично (математическо), или комбинация от двете споменати.

Клауза 8: Свобода на публикуване на научни резултати

Окаяно и жалко цензориране на научни статии сега се е превърнало в стандартна практика на редакторските бордове на важни списания и електронни архиви, и тяхната банда от набедени експертни рецензенти. Рецензентите в голяма част са предпазени от гарантираната анонимност така че авторът не може да е сигурен в тяхната компетентност. Статии сега рутинно се отхвърлят поради това, че авторът не е съгласен или се противопоставя на общоприето предпочитана теория или преобладаваща правоверност. Много статии сега се отхвърлят автоматично само защото сред авторите се появява името на учен, който е имал пререкания с редакторите на списанието, рецензентите, или други експертни цензори, като въобще и не се поглежда съдържанието на отхвърлената статия. Съществуват "черни листи" на инакомислещи учени и този лист се разпространява между редакторските бордове на списания които имат един и същ участващ редактор. Всичко това спомага за голямо пристрастие и престъпно потискане на свободната мисъл, и би трябвало да бъдат заклеймени от международната научна общност.

Всички учени трябва да имат право да представят техните научни резултати, изцяло или частично, на съответни научни конференции, както и да ги публикуват в отпечатвани научни списания, електронни архиви, или всякаква друга медия. Никой учен не трябва да получава отказ за публикуване на изпратена от него работа просто защото е подложил на въпрос мнението на сегашното мнозинство, съществува конфликт с мнението на редакторския борд, подкопава устоите на текущи или планирани от други учени изследвания, е в конфликт с някаква политическа догма, религиозно изповедание, или личното мнение на някого, и никой учен не трябва да бъде поставян в "черна листа", цензуриран или недопускан да публикува поради някого си. Никой учен не бива да блокира, модифицира, или по друг начин възпрепятства публикацията на работа на друг учен поради какъвто и да е било обещан подкуп.

Клауза 9: Съавторство на научни статии

Слабо пазена тайна в научните кръгове е, че много съавтори на научни статии всъщност имат малък или даже никакъв принос относно докладваните в публикацията резултати. Много ръководители на докторанти например нямат нищо против да си поставят името заедно с автора на който те са ръководители. В много от случаите човекът, който пише статията е интелектуално понапред от формалния си ръководител. В други случаи, отново заради желание за именитост, репутация, пари, престиж и други подобни, не участвали в проучването хора биват включвани в статията като съавтори. По този начин действителния автор може да отговаря на противопоставени алтернативни възгледи но само с риск след това да бъде наказан по някакъв начин, или рискува да не получи научната си степен. Много всъщност биват изхвърлени и не завършват научната си степен поради тази причина. Такава безобразна практика не може да бъде толерирана. Само хора, които са отговорни за изследването трябва да бъдат официално обявени за съавтори.

Никой учен не трябва да кани друг човек да бъде включен и никой учен не бива да позволява да бъде включен като съавтор на научна статия, ако те не са допринесли значимо за резултатите публикувани в статията. Никой учен не бива да позволява да бъде насилен от представител на дадена академична институция, корпорация, правителствена агенция, или друг човек, за да бъдат имената на тези хора включени като съавтор в изследване проведено от учения в което те не са допринесли значимо, както и учения не бива да предоставя името си за употреба като съавтор в замяна на подаръци или друг подкуп. Никой човек не бива да убеждава или да се опитва да убеждава учен, по какъвто и да е било начин, за да може името на учения да бъде включено като съавтор на научна статия относно резултати за които учения не е допринесъл значимо.

Клауза 10: Независимост на учения от връзки с институция

Много учени сега биват наемани с краткотрайни договори. С прекратяване на трудовия договор се прекратява и академичната връзка с дадена институция. Честа политика на редакторските бордове на списания е да не публикуват статии на хора без връзка с академична или комерсиална институция. Поради липсата на връзка с институция много възможности остават недостъпни за учения, а също така шансовете му да представя лекции и статии на конференции биват редуцирани. Това е порочна практика, която трябва да бъде спряна. Науката не признава връзките с институция.

Нито един учен не бива да бъде възпрепятстван да представя статии на конференции, колоквиуми или семинари, да публикува резултатите си във всякаква медия, да има достъп до академични библиотеки или научни публикации, да посещава научни срещи, да чете лекции, да иска връзка с дадена академична институция, научен институт, правителствена или комерсиална лаборатория, или друга организация.

Клауза 11: Отворен достъп до научна информация

Повечето специализирани книги относно научна информация, както и много научни списания, имат малка или не носят никаква печалба, така че комерсиални издателски къщи не желаят да публикуват такива творби без да им се заплати от академичната институция, правителствена агенция, филантропска фондация, или други подобни. При такива обстоятелства комерсиалните издателски къщи трябва да предоставят свободен достъп до електронните версии на публикуваните научни материали, и да се борят да редуцират цената на отпечатаните от тях публикации до минимум.

Нека всички учени се борят за осигуряване на неплатен достъп до техните научни публикации, или ако това не е възможно, то достъпът да е на минимална цена. Всички учени трябва да предприемат активни мерки, за да могат техните специализирани книги да бъдат достъпни на възможно най-малка цена по този начин правейки научната информация широко достъпна за международното научно общество.

Клауза 12: Морална отговорност на учените

Историята ни учи, че научните открития се използват както за добро така и за зло, за полза на едни и разоряване на други. Тъй като прогресът на науката и технологията не може да бъде спрян, то трябва да бъдат предприети мерки за ограничаване на потенциални злосторни приложения. Само демократично избрано правителство, свободно от религиозни, расистки или други предразсъдъци, може да охранява цивилизацията. Единствено демократично избрано правителство, трибунал или комитет могат да охраняват правото на свобода на научно създаване. Днес, различни недемократични страни или тоталитарни режими активно провеждат изследвания в областта на ядрената физика, химия, вирусология, генетично инжинерство, и други науки, за да могат да продуцират ядрено, химическо или биологическо оръжие. Нито един учен не бива да сътрудничи на недемократични страни или тоталитарни режими. Всеки учен принуден да работи за разработка на оръжие на такива страни трябва да намери начин и средства да забави развитието на изследователските програми и да редуцира научната производителност, за да може цивилизацията и демокрацията да възтържествуват.

Всички учени носят морална отговорност за собствените научни разработки и открития. Нито един учен не бива доброволно да се въвлича в дизайн или конструкция на каквито и да е било оръжия за недемократични страни или тоталитарни режими, или да позволява неговите научни умения и знание да бъдат приложени за разработване на нещо което може да навреди на човечеството. Ученият трябва да живее с мисълта, че всяко недемократично правителство или незачитане на човешките права е престъпление.

Март 12, 2007

Open Letter by the Editor-in-Chief: Declaration of Academic Freedom (Scientific Human Rights)
*The Romanian Translation**

Declaraţie asupra Libertăţii Academice

(Drepturile Omului în Domeniul Ştiinţific)

Articolul 1: Introducere

Inceputul secolului al 21-lea reflectă mai mult decât oricând în istoria omenirii, rolul adânc şi significant al ştiinţei şi tehnologiei în activităţile umane.

Natura atotpătrunzătoare şi universală a ştiinţei şi tehnologiei moderne a dat naştere unei percepţii comune că viitoarele descoperiri importante pot fi făcute, în principal sau în exclusivitate, numai de grupuri mari de cercetare finanţate de guvernări sau de firme mari, care au access la instrumente foate scumpe precum şi la un număr mare de personal de support.

Această percepţie comună, este totuşi nerealistă şi contrazice modul adevărat în care sunt făcute descoperirile ştiinţifice. Proiecte tehnologice mari şi scumpe, oricât de complexe, sunt numai rezultatul aplicării profundei intuiţii ştiinţifice a unor grupuri mici de cercetători dedicaţi sau a unor oameni de ştiinţă solitari, care de multe ori lucrează izolaţi. Un om de ştiinţă care lucrează singur, este, acum precum şi în viitor, aşa cum a fost şi în trecut, capabil să facă o descoperire, care poate influenţa substanţial soarta omenirii şi poate schimba faţa întegii planete pe care o locuim pentru aşa de puţin timp.

Descoperirile cele mai importante sunt făcute de persoane care lucreaza ca subalterni în diverse agenţii guvernamentale, instituţii de învăţământ şi cercetare, sau intreprinderi comerciale. În consecinţă, cercetătorul este foare frecvent forţat sau umbrit de directorii instituţiilor şi firmelor, care, având planuri diferite, caută să controleze şi să aplice descoperirile ştiintifice şi cercetările pentru profit personal sau pentru organizaţie, sau prestigiu personal.

Recordul istoric al decoperirilor ştiinţifice abundă în cazuri de represiune şi ridiculizare făcute de cei la putere, dar în ultimii ani acestea au fost dezvăluite si corectate de către inexorabilul progres al necesităţii practice şi iluminare intelectuală. Tot aşa de rău arată şi istoria distrugerii şi degradării produse prin plagiarism şi denaturare intenţionată, făcute de necinstiţi, motivaţi de invidie şi lăcomie. Şi aşa este şi azi.

Intenţia acestei Declaraţii este să sprijine şi să dezvolte doctrina fundamentală că cercetarea ştiinţifică trebuie să fie liberă de influenţa ascunsă şi făţiş represivă a directivelor birocratice, politice, religioase, pecuniare şi, de asemenea, creaţia ştiinţifică este un drept al omului, nu mai mic decât alte drepturi similare şi speranţe disperate care sunt promulgate in acorduri şi legi internaţionale.

Toţi oamenii de ştiinţă care sunt de acord vor trebui să respecte aceasta Declaraţie, ca o indicaţie a solidarităţii cu comunitatea ştiinţifică internaţională care este preocupată de acest subiect, şi să asigure drepturile cetăţenilor lumii la creaţie ştiinţifică fără amestec, în acordanţă cu talentul şi dispoziţia fiecăruia, pentru progresul ştiinţei şi conform abilităţii lor maxime ca cetăţeni decenţi într-o lume indecentă, în avantajul Omenirii. Stiinţa şi tehnologia au fost pentru prea multă vreme servanţii asupririi.

Articolul 2: Cine este un cercetător ştiinţific

Un cercetător ştiinţific este orice persoană care se preocupă de ştiinţă. Orice persoană care colaborează cu un cercetător în dezvoltarea şi propunerea ideilor şi a informaţiilor într-un project sau aplicaţie, este de asemenea un cercetător. Deţinerea unor calificări formale nu este o cerinţă prealabilă pentru ca o persoană să fie un cercetător ştiinţific.

Articolul 3: Unde este produsă ştiinţa

Cercetarea ştiinţifică poate să aibă loc oriunde, de exemplu, la locul de muncă, în timpul studiilor, în timpul unui program academic sponsorizat, în grupuri, sau ca o persoană singură acasă făcând o cercetare independentă.

Articolul 4: Libertatea de a alege o temă de cercetare

Mulţi cercetători care lucrează pentru nivele mai avansate de cercetare sau în alte programe de cercetare la instituţii academice, cum sunt universităţile şi facultăţile de studii avansate, sunt descurajaţi, de personalul de conducere academic sau de oficiali din administraţie, de a lucra în domeniul lor preferat de cercetare, şi aceasta nu din lipsa mijloacelor de suport, ci din cauza ierarhiei academice sau a altor oficialităţi, care pur şi simplu nu aprobă o direcţie de cercetare să se dezvolte la potenţialul ei, ca să nu deranjeze dogma convenţională, teoriile favorite, sau subvenţionarea altor proiecte care ar putea fi discreditate de cercetarea propusă. Autoritatea majorităţii ortodoxe este destul de frecvent invocată ca să stopeze un proiect de cercetare, astfel încât autorităţile şi bugetul să nu fie deranjate. Această practică

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comună este o obstrucţie deliberată a gândirii libere, este neştiinţifică la extrem, şi este criminală. Aceasta nu poate fi tolerată.

Un cercetător care lucrează pentru orice instituţie academică, organizaţie, sau agenţie trebuie să fie complet liber în alegerea unei teme de cercetare şi să fie limitat doar de suportul material şi de expertiza intelectuală care poate fi oferită de instituţia academică, organizaţia, sau agenţia respectivă. Dacă un cercetător îşi desfăsoară activitatea lui de cercetare fiind membru al unui grup de cercetători, atunci directorii de cercetare şi liderii grupului îşi vor limita rolul lor doar la capacitatea de recomandare şi consultanţă în ceea ce priveşte alegerea unei teme de cercetare relevante de către un cercetător din grup.

Articolul 5: Libertatea de alegere a metodelor de cercetare

În multe cazuri personalul administrativ sau academic de conducere impune o anumită presiune asupra unor cercetători, care fac parte dintr-un program de cercetare care se desfăşoară într-un mediu academic, ca să-i forţeze să adopte alte metode de cercetare decât acelea alese de ei, motivul fiind nu altul decât o preferinţă personală, o prejudecată, o procedură instituţională, ordine editorială, ori autoritate colectivă. Această practică, care este destul de răspândită, este o eliminare deliberată a libertăţii de gândire, şi această nu poate fi permisă.

Un cercetator academic sau dintr-o instituţie care nu lucrează pentru profit are dreptul să dezvolte o temă de cercetare în orice mod rezonabil, utilizând orice mijloace rezonabile pe care el le consieră că vor fi cele mai eficiente. Doar cercetătorul însuşi ia decizia finală asupra modului cum cercetarea va fi efectuată.

Dacă un cercetator academic, sau dintr-o instituţie care nu lucrează pentru profit, lucrează ca un membru al unui grup de cercetători academici, sau dintr-o instituţie care nu lucrează pentru profit, conducătorii de proiect şi directorii de cercetare vor avea doar un rol de îndrumători şi consultanţi şi nu trebuie în nici un fel să influenţeze, să intervină, sau să limiteze metodele de cercetare sau tema de cercetare ale unui cercetător din grup.

Articolul 6: Libertatea de participare şi colaborare în cercetare

În practicarea ştiinţei moderne există un element semnificant de rivalitate instituţională, concomitent cu elemente de invidie personală şi de prezervare a reputaţiei cu orice preţ, indiferent de realităţile ştiinţifice. Aceasta de multe ori a condus la faptul că cercetătorii au fost împiedicaţi să nominalizeze asistenţa colegilor competenţi care fac parte din instituţii rivale sau alţii care nu au nici o afiliaţie academică. Această practică este de asemenea o obstrucţie deliberată a progresului ştiinţific.

Dacă un cercetator ştiinţific dintr-o instituţie care nu lucrează pentru profit cere asistenţa unui alt cercetător şi dacă acel cercetător este de accord, cercetătorul are libertatea de a invita celălalt cercetător să-i ofere orice asistenţă, cu condiţia ca asistenţa să fie în cadrul bugetului de cercetare stabilit. Dacă asistenţa este independentă de buget, cercetătorul are libertatea să angajeze cercetătorul colaborator la discreţia lui, făra absolut nici o intervenţie din partea nici unei alte persoane.

Articolul 7: Libertatea de a nu fi de accord în discuţii ştiinţifice

Datorită invidiei ascunse şi a intereselor personale, ştiinţa modernă nu apreciază discuţii deschise şi nu acceptă în mod categoric pe acei cercetători care pun la îndoială teoriile ortodoxe. Deseori, cercetători cu abilităţi deosebite, care arată deficienţele într-o teorie actuală sau într-o interpretare a datelor, sunt denumiţi excentrici, astfel ca vederile lor să poată fi ignorate cu uşurinţă. Ei sunt făcuţi de râs în public şi în discuţii personale şi sunt opriţi în mod sistematic de a participa la convenţii, seminarii, sau colocvii ştiinţifice, astfel ca ideile lor să nu poată să găsească o audienţă. Falsificări deliberate ale datelor şi reprezentarea greşită a teoriei sunt acum unelte frecvente ale celor fără scrupule, în eliminarea dovezilor, atât tehnice cât şi istorice. Comitete internaţionale de cercetători rău-intenţionaţi au fost formate şi aceste comitete organizează şi conduc convenţii internaţionale, unde numai cei care sunt de accord cu ei sunt admişi să prezinte lucrări, indiferent de calitatea acestora. Aceste comitete extract sume mari de bani din bugetul public ca să suporte proiectele lor preferate, folosind falsităţi şi minciuni. Orice obiecţiune la propunerile lor, pe baze ştiinţifice, este trecută sub tăcere prin orice mijloace la dispoziţia lor, aşa ca banii să poată să continue să se verse la conturile proiectelor lor şi să le garanteze posturi bine plătite. Cercetătorii care s-au opus au fost daţi afară la cererea acestor comitete, alţii au fost împiedicaţi, de către o reţea de complici corupţi, de a obţine posturi academice. În alte situaţii unii au fost daţi afară de la candidatura pentru titluri academice avansate, cum ar fi doctoratul, pentru că şi-au exprimat idei care nu sunt de accord cu teoria la modă, chiar dacă această teorie ortodoxă la modă este în vigoare de multă vreme. Ei ignoră complet faptul fundamental că nici o teorie ştiinţifică nu este definitivă şi inviolabilă, şi prin urmare este deschisă pentru discuţii şi re-examinare. De asemenea ei ignoră faptul că un fenomen ar putea să aibă mai multe explicaţii plauzibile, şi în mod răutăcios discreditează orice explicaţie care nu este de acord cu opinia ortodoxă, folosind fără nici o restricţie argumente neştiinţifice să explice opiniile lor părtinitoare.

Toţi cercetătorii trebuie să fie liberi să discute cercetările lor şi cercetările altora, fără frica de a fi ridiculizaţi, fără nici o bază materială, în public sau în discuţii particulare, sau să fie acuzaţi, criticaţi, nerespectaţi sau discreditaţi în alte feluri, cu afirmaţii nesubstanţiate. Nici un cercetător nu trebuie să fie pus într-o poziţie în care situaţia sau reputaţia lui vor fi riscate, datorită exprimării unei opinii ştiinţifice. Libertatea de exprimare ştiinţifică trebuie să fie supremă. Folosirea autorităţii în respingerea unui argument ştiinţific este neştiinţifică şi nu trebuie să fie folosită ca să oprească, să anuleze, să intimideze, să ostracizeze, sau să reducă la tăcere ori să interzică în orice fel un cercetător. Înterzicerea deliberată a faptelor sau argumentelor ştiinţifice, fie prin fapte sau prin omitere, şi falsificarea deliberată a datelor, ca să suporte un argument sau ca să discrediteze un punct de vedere opus, este o decepţie ştiinţifică, care poate fi numită crimă ştiinţifică. Principiile de evidenţă trebuie să fie călăuza discuţiei ştiinţifice, fie că acea evidenţa este fizică sau teoretică sau o combinaţie a lor.

Articolul 8: Libertatea de a publica rezultate ştiinţifice

O cenzură deplorabilă a articolelor ştiinţifice a devenit acum practica standard a editorilor multor jurnale de specialitate şi arhive electronice, şi a grupurilor lor de aşa zişi referenţi experţi. Referenţii sunt, în majoritate, protejaţi prin anonimitate aşa încât un autor nu le poate verifica aşa zisa lor expertiză. Lucrările sunt acum de obicei respinse dacă autorul nu este de accord sau contrazice teorii preferate şi ortodoxia majoritară. Multe lucrări sunt acum respinse în mod automat bazat pe faptul că în bibliografie apare citat un cercetător care nu este în graţiile editorilor, referenţilor, sau al altor cenzori experţi, cu nici un fel de consideraţie faţă de conţinutul lucrării. Există o listă neagră a cercetătorilor care sunt în opoziţie şi această listă este comunicată între conducerile editurilor. Toate acestea duc la o crasă prejudecare şi o represiune greşită împotriva gândirii libere şi trebuie condamnate de comunitatea internaţională a cercetătorilor.

Toţi cercetătorii trebuie să aibă dreptul să prezinte rezultatele cercetărilor lor ştiinţifice, în totalitate sau parţial, la conferinţe ştiinţifice relevante, şi să le publice în jurnale ştiinţifice tipărite, arhive electronice sau in altă media. Cercetătorilor nu trebuie să li se respingă lucrările sau rapoartele lor când sunt prezentate spre publicare în jurnale ştiinţifice, arhive electronice, sau in altă media, numai pentru motivul că lucrările lor pun sub semn de întrebare opinia majoritară curentă, este în contradicţie cu opiniile unei conduceri editoriale, zdruncină bazele altor proiecte de cercetare prezente sau de viitor ale altor cercetători, este în conflict cu orice dogmă politică sau doctrină religioasă, sau cu opinia personală a cuiva, şi nici un cercetător ştiinţific nu trebuie să fie pe lista neagră sau cenzurat şi împiedicat de la publicare de nici o altă persoană. Nici un cercetător ştiinţific nu trebuie să blocheze, modifice, sau să se amestece în orice mod la publicarea lucrării unui cercetător deoarece îi sunt promise cadouri sau alte favoruri.

Artiolul 9: Publicând articole ştiinţifice în calitate de co-autor

In cercurile ştiinţifice este un secret bine cunoscut, că mulţi co-autori ai lucrărilor de cercetare au foarte puţin sau nimic în comun cu rezultatele prezentate. Mulţi conducători de teze ale studenţilor, de exemplu, nu au nici o problemă să-şi pună numele pe lucrările candidaţilor pe care numai formal îi coordonează. În multe cazuri dintre acestea, persoana care de fapt scrie lucrarea are o inteligenţă superioară celei a coordinatorului. In alte situaţii, din nou, pentru motive de notorietate, reputaţie, bani, prestigiu, şi altele, neparticipanţi sunt incluşi în lucrare în calitate de co-autori. Adevăraţii autori ai acestor lucrări pot să obiecteze numai cu riscul de a fi penalizaţi mai târziu într-un mod sau altul, sau chiar riscând să fie excluşi de la candidatura pentru grade superioare de cercetare sau din grupul de cercetare. Mulţi au fost de fapt eliminaţi din aceste motive. Această teribilă practică nu poate fi tolerată. Numai acele persone responsabile pentru cercetare trebuie să fie creditaţi ca autori.

Cercetatorii nu trebuie să invite alte persoane să fie co-autori şi nici un cercetător nu ar trebui să admită ca numele lui să fie inclus în calitate de co-autor la o lucrare ştiinţifică, dacă nu au avut o contribuţie substanţială la cercetarea prezentată în lucrare. Nici un cercetător nu trebuie să se lase forţat de nici un reprezentant al unei instituţii academice, firmă, agenţie guvernamentală, sau orice altă persoană să devină co-autor la o lucrare, dacă ei nu au avut o contribuţie significantă pentru acea lucrare, şi nici un cercetător nu trebuie să accepte să fie co-autor în schimb pentru pentru cadouri sau alte gratuităţi. Nici o persoană nu trebuie să încurajeze sau să încerce să încurajeze un cercetător, în orice modalitate, să admită ca numele său să fie inclus în calitate de co-autor al unei lucrări ştiinţifice pentru care ei nu au adus o contribuţie semnificativă.

Articolul 10: Independenţa afiliaţiei

Mulţi cercetători sunt angajaţi prin contracte de scurtă durată. Odată cu terminarea contractului se termină şi afiliaţia academică. Este frecventă practica conducerii editurilor ca persoanelor fără afiliaţie academică sau comercială să nu li se publice lucrările. Când cercetătorul nu este afiliat, el nu are resurse şi deci are oportunităţi reduse să participe şi să prezinte lucrări la conferinţe. Aceasta este o practică vicioasă care trebuie stopată. Ştiinţa nu recunoaşte afiliaţie.

Nici un cercetător nu trebuie să fie împiedicat de la prezentarea de lucrări la conferinţe, colocvii sau seminarii, de la publicarea în orice media, de la acces la biblioteci academice sau publicaţii ştiinţifice, de la participarea la şedinţe academice, sau de la prezentarea de prelegeri, din cauză că nu are o afiliere cu instituţii academice, institute de cercetare, laboratoare guvernamentale sau comericale, sau cu orice altă organizaţie.

Articolul 11: Acces deschis la informaţia ştiinţifică

Multe cărţi ştiinţifice de specialitate şi multe jurnale ştiinţifice au un profit mic sau nici un profit, de aceea editorii refuză să le publice fără o contribuţie monetară de la instittţiile academice, agenţii guvernamentale, fundaţii filantropice, şi altele. În aceste circumstanţe editorii ar trebui să dea acces liber la versiunile electronice ale publicaţiilor, şi să se străduiască să menţină costul pentru tipărirea materialului la minim.

Toţi cercetătorii trebuie să se străduiască să se asigure ca lucrările lor să fie gratuite şi accesibile la comunitatea ştiinţifică internaţională, sau, dacă nu este posibil, la un preţ modest. Toţi cercetătorii trebuie să ia măsuri active ca să ofere cărţile lor tehnice la cel mai mic preţ posibil, pentru ca informaţia ştiinţifică să devină accesibilă marii comunităţi ştiinţifice internaţionale.

Articolul 12: Responsabiltatea etică a cercetătorilor

Istoria este martoră că descoperirile ştiinţifice sunt folosite în ambele direcţii, bune şi rele, pentru binele unora şi pentru distrugerea altora. Deoarece progresul ştiinţei şi tehnologiei nu poate fi oprit, trebuie să avem metode de control asupra applicaţiilor rău făcătoare. Doar guvernele alese democratic, eliberate de religie, de rasism şi alte prejudicii, pot să protejeze civilizaţia. Doar guvernele, tribunalele şi comitetele alese democratic pot proteja dreptul la o creaţie ştiinţifică liberă. Astăzi, diferite state nedemocratice şi regime totalitare performă o activă cercetare în fizica nucleară, chimie, virologie, inginerie genetică, etc. ca să producă arme nucleare, chimice şi biologice. Nici un cercetător nu trebebuie să colaboreze voluntar cu state nedemocratice sau regime totalitare. Orice cercetător forţat să lucreze în crearea de arme pentru astfel de state trebuie să găsească mijloace de a încetini progresul programelor de cercetare şi să reducă rezultatele ştiinţifice, astfel încât civilizaţia şi democraţia în cele din urmă să triumfe.

Toţi cercetătorii au o responsabilitate morală pentru descoperirile şi rezultatele lor ştiinţifice. Nici un cercetător să nu se angajeze de bună voie în proiectarea sau construcţia a nici unui fel de armament pentru state cu regimuri nedemocratice sau totalitare sau să accepte ca talentele şi cunoştiinţele lor să fie aplicate în crearea de arme care vor conduce la distrugerea Omenirii. Un cercetător ştiinţific trebuie să trăiască aplicând dictonul că toate guvernele nedemocratice şi violarea drepturilor umane sunt crime.

14 martie, 2007

Open Letter by the Editor-in-Chief: Declaration of Academic Freedom (Scientific Human Rights)
*The French Translation**

Déclaration de la Liberté Académique

(Les Droits de l'Homme dans le Domaine Scientifique)

Article 1: Préambule

Le début du 21ème siècle reflète, plus qu'aucun autre temps de l'histoire, la profondeur et l'importance de la science et la technologie dans les affaires humaines.

La nature puissante et influente de la science et la technologie modernes a fait naître une perception commune voulant que les prochaines grandes découvertes ne peuvent être faites principalement ou entièrement que par des groupes de recherche qui sont financés par des gouvernements ou des sociétés et ont accès à une instrumentation dispendieuse et à des hordes de personnel de soutien.

Cette perception est cependant mythique et donne une fausse idée de la façon dont des découvertes scientifiques sont faites. Les grands et coûteux projets technologiques, aussi complexes qu'ils soient, ne sont que le résultat de l'application de la perspicacité des petits groupes de recherche ou d'individus dévoués, travaillant souvent seuls ou séparément. Un scientifique travaillant seul est, maintenant et dans le futur, comme dans le passé, capable de faire une découverte qui pourrait influencer le destin de l'humanité.

Les découvertes les plus importantes sont généralement faites par des individus qui sont dans des positions subalternes au sein des organismes gouvernementaux, des établissements de recherche et d'enseignement, ou des entreprises commerciales. Par conséquent, le rechercheur est trop souvent restraint par les directeurs d'établissements ou de la société, qui ont des ambitions différentes, et veulent contrôler et appliquer les découvertes et la recherche pour leur bien-être personnel, leur agrandissement, ou pour le bien-être de leur organisation.

L'histoire est remplie d'exemples de suppression et de ridicule par l'établissement. Pourtant, plus tard, ceux-ci ont été exposés et corrigés par la marche inexorable de la nécessité pratique et de l'éclaicissement intellectuel. Tristement, la science est encore marquée par la souillure du plagiat et l'altération délibérée des faits par les sans-scrupules qui sont motivés par l'envie et la cupidité; cette pratique existe encore aujourd'hui.

L'intention de cette Déclaration est de confirmer et promouvoir la doctrine fondamentale de la recherche scientifique; la recherche doit être exempte d'influences suppressive, latente et manifeste, de directives bureaucratiques, politiques, religieuses et pécuniaires. La création scientifique doit être un droit de l'homme, tout comme les droits et espérances tels que proposés dans les engagements internationaux et le droit international.

Tous les scientifiques doivent respecter cette Déclaration comme étant signe de la solidarité dans la communauté scientifique internationale. Ils défendront les droits à la création scientifique libre, selon leurs différentes qualifications, pour l'avancement de la science et, à leur plus grande capacité en tant que citoyens honnêtes dans un monde malhonnête, pour permettre un épanouissement humain. La science et la technologie ont été pendant trop longtemps victimes de l'oppression.

Article 2: Qu'est-ce qu'un scientifique

Un scientifique est une personne qui travaille en science. Toute personne qui collabore avec un scientifique en développant et en proposant des idées et des informations dans la recherche, ou son application, est également un scientifique. Une formation scientifique formelle n'est pas un prérequis afin d'être un scientifique.

Article 3: Le domaine de la science

La recherche scientifique existe n'importe où, par exemple, au lieu de travail, pendant un cours d'éducation formel, pendant un programme universitaire commandité, dans un groupe, ou en tant qu'individu à sa maison conduisant une recherche indépendante.

Article 4: Liberté du choix du thème de recherche

Plusieurs scientifiques qui travaillent dans des échelons plus élevés de recherche tels que les établissements académiques, les universités et les institutions, sont empêchés de choisir leurs sujets de recherche par l'administration universitaire, les scientifiques plus haut-placés ou par des fonctionnaires administratifs. Ceci n'est pas par manque d'équipements, mais parce que la hiérarchie académique et/ou d'autres fonctionnaires n'approuvent pas du sujet d'une enquête qui pourrait déranger le dogme traditionnel, les théories favorisées, ou influencer négativement d'autres projets déjà proposés. L'autorité plutôt traditionnelle est souvent suscitée pour

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faire échouer un projet de recherche afin de ne pas déranger l'autorité et les budgets. Cette pratique commune est une obstruction délibérée à la science, ainsi que la pensée scientifique et démontre un élément anti-scientifique à l'extrême; ces actions sont criminelles et ne peuvent pas être tolérées.

Un scientifique dans n'importe quel établissement académique, institution ou agence, doit être complètement libre quant au choix d'un thème de recherche. Il peut être limité seulement par l'appui matériel et les qualifications intellectuelles offertes par l'établissement éducatif, l'agence ou l'institution. Quand un scientifique effectue de la recherche collaborative, les directeurs de recherche et les chefs d'équipe seront limités aux rôles de consultation et de recommandation par rapport au choix d'un thème approprié pour un scientifique dans leur groupe.

Article 5: Liberté de choisir ses méthodes et ses techniques de recherche

Souvent les scientifiques sont forcés par le personnel administratif ou académique à adopter des méthodes de recherches contraires à celles que le scientifique préfère. Cette pression exercée sur un scientifique contre son gré est à cause de la préférence personnelle, le préjugé, la politique institutionnelle, les préceptes éditoriaux, ou même l'autorité collective. Cette pratique répandue va à l'encontre la liberté de pensée et ne peut pas être permise ni toléreé.

Un scientifique travaillant à l'extérieur du secteur commercial doit avoir le droit de développer un thème de recherche de n'importe quelle manière et moyens raisonnables qu'il considère les plus efficaces. La décision finale sur la façon dont la recherche sera executée demeure celle du scientifique lui-même.

Quand un scientifique travaille en collaboration, il doit avoir l'indépendance de choisir son thème et ses méthodes de recherche, tandis que les chefs de projets et les directeurs auront seulement des droits de consultatition et de recommandation, sans influencer, atténuer ou contraindre les méthodes de recherches ou le thème de recherche d'un scientifique de leur groupe.

Article 6: Liberté de participation et de collaboration en recherche

La rivalité entre les différentes institutions dans la science moderne, la jalousie personnelle et le désir de protéger sa réputation à tout prix empêchent l'entraide parmi des scientifiques qui sont aussi compétents les uns que les autres mais qui travaillent dans des établissements rivaux. Un scientifique doit avoir recours à ses collègues dans un autre centre de recherche.

Quand un premier scientifique qui n'a aucune affiliation commerciale a besoin de l'aide et qu'il invite un autre scientifique, ce deuxième est libre d'accepter d'aider le premier si l'aide demeure à l'intérieur du budget déjà établi. Si l'aide n'est pas dépendante des considérations budgetaires, le premier scientifique a la liberté d'engager le deuxième à sa discrétion sans l'interposition des autres. Le scientifique pourra ainsi rémunérer le deuxième s'il le désire, et cette décision demeure à sa discrétion.

Article 7: Liberté du désaccord dans la discussion scientifique

À cause de la jalousie et des intérêts personnels, la science moderne ne permet pas de discussion ouverte et bannit obstinément ces scientifiques qui remettent en cause les positions conventionnelles. Certains scientifiques de capacité exceptionnelle qui précisent des lacunes dans la théorie ou l'interprétation courante des données sont étiquetés comme cinglés, afin que leurs opinions puissent être facilement ignorées. Ils sont raillés en public et en privé et sont systématiquement empêchés de participer aux congrès scientifiques, aux conférences et aux colloques scientifiques, de sorte que leurs idées ne puissent pas trouver une audience. La falsification délibérée des données et la présentation falsifiée des théories sont maintenant les moyens utlilisés habituellement par les sans-scrupules dans l'étouffement des faits, soit techniques soit historiques. Des comités internationaux de mécréants scientifiques ont été formés et ces mêmes comités accueillent et dirigent des conventions internationales auxquelles seulement leurs acolytes sont autorisés à présenter des articles sans tenir compte de la qualité du travail. Ces comités amassent de grandes sommes d'argent de la bourse publique et placent en premier leurs projets commandités et fondés par la déception et le mensonge. N'importe quelle objection à leurs propositions, pour protéger l'intégrité scientifique, est réduite au silence par tous leur moyens, de sorte que l'argent puisse continuer à combler leurs comptes et leur garantir des emplois bien payés. Les scientifiques qui s'y opposent se font renvoyer à leur demande; d'autres ont été empêchés de trouver des positions académiques par ce réseau de complices corrompus. Dans d'autres situations certains ont vu leur candidature expulsée des programmes d'‘études plus élevés, tels que le doctorat, après avoir ébranlé une théorie à la mode, même si une théorie plus conventionnelle existe depuis plus longtemps. Le fait fondamental qu'aucune théorie scientifique est ni définitive ni inviolable, et doit être ré-ouverte, dicutée et ré-examinée, ils l'ignorent complètement. Souvent ils ignorent le fait qu'un phénomène peut avoir plusieurs explications plausibles, et critiquent avec malveillance n'importe quelle explication qui ne s'accorde pas avec leur opinion. Leur seul recours est l'utilisation d'arguments non scientifiques pour justifier leurs avis biaisés.

Tous les scientifiques seront libres de discuter de leur recherche et la recherche des autres sans crainte d'être ridiculisés, sans fondement matériel, en public ou en privé, et sans êtres accusés, dénigrés, contestés ou autrement critiqués par des allégations non fondées. Aucun scientifique ne sera mis dans une position dans laquelle sa vie ou sa réputation sera en danger, dû à l'expression de son opinion scientifique. La liberté d'expression scientifique sera primordiale. L'autorité ne sera pas employée dans la réfutation d'un argument scientifique pour bâillonner, réprimer, intimider, ostraciser, ou autrement pour contraindre un scientifique à l'obéissance ou lui faire obstacle. La suppression délibérée des faits ou des arguments scientifiques, par acte volontaire ou par omission, ainsi que la modification délibérée des données pour soutenir un argument ou pour critiquer l'opposition constitue une fraude scientifique qui s'élève jusqu'à un crime scientifique. Les principes de l'évidence guideront toutes discussions scientifiques, que cette évidence soit concrète, théorique ou une combinaison des deux.

Article 8: Liberté de publier des résultats scientifiques

La censure déplorable des publications scientifiques est maintenant devenue la norme des bureaux de rédaction, des journaux et des archives électroniques, et leurs bandes de soit-dits arbitres qui prétent être experts. Les arbitres sont protégés par l'anonymat, de sorte qu'un auteur ne puisse pas vérifier l'expertise prétendue. Des publications sont maintenant rejetées si l'auteur contredit, ou est en désaccord avec, la théorie préférée et la convention la plus acceptée. Plusieurs publications sont rejetées automatiquement parce qu'il y a un des auteurs dans la liste qui n'a pas trouvé faveur avec les rédacteurs, les arbitres, ou d'autres censureurs experts, sans respect quelconque pour le contenu du document. Les scientifiques discordants sont mis sur une liste noire et cette liste est communiquée entre les bureaux de rédaction des participants. Cet effet culmine en un penchant biaisé et une suppression volontaire de la libre pensée, et doit être condamné par la communauté scientifique internationale.

Tous les scientifiques doivent avoir le droit de présenter leurs résultats de recherche, en entier ou en partie, aux congrès scientifiques appropriés, et d'éditer ceux-ci dans les journaux scientifiques, les archives électroniques, et tous les autres médias. Aucun scientifique ne se fera rejeter ses publications ou rapports quand ils seront soumis pour publication dans des journaux scientifiques, des archives électroniques, ou d'autres médias, simplement parce que leur travail met en question l'opinion populaire de la majorité, fait conflit avec les opinions d'un membre de rédaction, contredit les prémisses de bases d'autres recherche ou futurs projets de recherche prévus par d'autres scientifiques, sont en conflit avec quelque sorte de dogme politique, religieuse, ou l'opinion personnelle des autres. Aucun scientifique ne sera mis sur une liste noire, ou sera autrement censuré pour empêcher une publication par quiconque. Aucun scientifique ne bloquera, modifiera, ou interfèrera autrement avec la publication du travail d'un scientifique sachant qu'il aura des faveurs ou bénifices en le faisant.

Article 9: Les publications à co-auteurs

C'est un secret mal gardé parmi les scientifiques que beaucoup de co-auteurs de publications ont réellement peu, ou même rien, en rapport avec la recherche présentée. Les dirigeants de recherche des étudiants diplômés, par exemple, préfèrent leurs noms inclus avec celui des étudiants sous leur surveillance. Dans de tels cas, c'est l'élève diplômé qui a une capacité intellectuelle supérieure à son dirigeant. Dans d'autres situations, pour des fins de notoriété et de réputation, d'argent, de prestige et d'autres raisons malhonnêtes, des personnes qui n'ont rien contribué sont incluses en tant que co-auteurs. Les vrais auteurs peuvent s'y opposer, mais seront pénalisés plus tard d'une manière quelconque, voir même l'expulsion de leur candidature pour un diplôme plus élevé, ou une mise à pied d'une équipe de recherche. C'est un vécu réel de plusieurs co-auteurs dans ces circonstances. Cette pratique effroyable ne doit pas être tolérée. Pour maintenir l'intégrité de la science, seulement les personnes chargées de la recherche devraient être reconnues en tant qu'auteurs.

Aucun scientifique n'invitera quiconque n'a pas collaboré avec lui à être inclus en tant que co-auteur, de même, aucun scientifique ne permettera que son nom soit inclus comme co-auteur d'une publication scientifique sans y avoir contribué de manière significative. Aucun scientifique ne se laissera contraindre par les représentants d'un établissement académique, par une société, un organisme gouvernemental, ou qui que ce soit à inclure leur nom comme co-auteur d'une recherche s'il n'y a pas contribué de manière significative. Un scientifique n'acceptera pas d'être co-auteur en échange de faveurs ou de bénéfices malhonnêtes. Aucune personne ne forcera un scientifique d'aucune manière à mettre son nom en tant que co-auteur d'une publication si le scientifique n'y a pas contribué de manière significative.

Article 10: L'indépendance de l'affiliation

Puisque des scientifiques travaillent souvent à contrats à court terme, quand le contrat est terminé, l'affiliation académique du scientifique est aussi terminée. C'est souvent la politique des bureaux de rédaction que ceux sans affiliation académique ou commerciale ne peuvent pas être publiés. Sans affiliation, beaucoup de ressources ne sont pas disponibles au scientifiques, aussi les occasions de présenter des entretiens et des publications aux congrès sont réduites. Cette pratique vicieuse doit être arrêtée. La science se déroule indépendamment de toutes affiliations.

Aucun scientifique ne sera empêché de présenter des publications aux congrès, aux colloques ou aux séminaires; un scientifique pourra publier dans tous les médias, aura accès aux bibliothèques académiques ou aux publications scientifiques, pourra assister à des réunions scientifiques, donner des conférences, et ceci même sans affiliation avec un établissement académique, un institut scientifique, un laboratoire gouvernemental ou commercial ou tout autre organisation.

Article 11: L'accès à l'information scientifique

La plupart des livres de science et les journaux scientifiques ne font pas de profits, donc les éditeurs sont peu disposés à les éditer sans une contribution financière des établissements académiques, des organismes gouvernementaux, des fondations philanthropiques et leur semblables. Dans ces cas, les éditeurs commerciaux doivent permettre le libre accès aux versions électroniques des publications et viser à garder le coût d'imprimerie à un minimum.

Les scientifiques s'efforceront d'assurer la disponibilité de leurs ouvrages à la communauté internationale gratuitement, ou à un coût minimum. Tous les scientifiques doivent faire en sorte que les livres de techniques soient disponibles à un coût minimum pour que l'information scientifique puisse être disponible à une plus grande communauté scientifique internationale.

Article 12: La responsabilité morale des scientifiques

L'histoire a démontré que des découvertes scientifiques sont parfois utilisées à des fins extrèmes, soit bonnes, soit mauvaises, au profit de certains et à la ruine des autres. Puisque l'avancement de la science et de la technologie continue toujours, des moyens d'empêcher son application malveillante doivent être établis. Puisqu'un gouvernement élu de manière démocratique, sans biais religieux, racial ou autres biais peut sauvegarder la civilisation, ainsi seulement le gouvernement, les tribunaux et les comités élu de manière démocratique peuvent sauvegarder le droit de la création scientifique libre et intègre. Aujourd'hui, divers états anti-démocratiques et régimes totalitaires font de la recherche active en physique nucléaire, en chimie, en virologie, en génétique, etc. afin de produire des armes nucléaires, chimiques ou biologiques. Aucun scientifique ne devrait volontairement collaborer avec les états anti-démocratiques ou les régimes totalitaires. Un scientifique qui est contraint à travailler au développement des armes pour de tels états doit trouver des moyens pour ralentir le progrès de cette recherche et réduire son rendement, de sorte que la civilisation et la démocratie puissent finalement régner.

Tous les scientifiques ont la responsabilité morale de leurs créations et découvertes. Aucun scientifique ne prendra volontairement part dans les ébauches ou la construction d'armes pour des états anti-démocratiques et/ou des régimes totalitaires, et n'appliquera ni ses connaissances ni son talent au développement d'armes nuisibles à l'humanité. Un scientifique suivra le maxime que tous les gouvernements anti-démocratiques et l'abus des droits de l'homme sont des crimes.

Le 10 avril, 2007

Open Letter by the Editor-in-Chief: Declaration of Academic Freedom (Scientific Human Rights)
*The Russian Translation**

Декларация Академической Свободы

(Права Человека в Научной Деятельности)

Статья 1: Преамбула

Начало 21-го *столетия больше, чем любая* другая эпоха в истории человечества, проявляет глубину и значение роли науки и техники в человеческих делах.

Интенсивное развитие современной науки и техники явилось причиной банального мнения, что все дальнейшие ключевые открытия в науке могут быть сделаны преимущественно или исключительно крупными исследовательскими группами (коллективами), финансируемыми исключительно на уровне государства или крупной корпорации, и, соответственно, имеющими доступ к очень дорогому экспериментальному оборудованию и большому количеству вспомогательного обслуживающего персонала.

Эта обычная точка зрения, однако, является мифом, и противоречит истинному положению дел с теоретическими и экспериментальными исследованиями в современной науке. В действительности крупные и дорогие технологические проекты — это всего лишь результат приложения фундаментальных научных знаний, полученных небольшими группами исследователей или вообще индивидуалами, часто работающими в отрыве от крупных научных коллективов и институтов. Ученый, работающий в одиночку — ныне, так же как и в прошлом — способен сделать открытие, которое может существенно повлиять на судьбу человечества и изменить лицо всей нашей планеты.

Большинство инновационных открытий вообще сделаны индивидуумами, работающими, в зависимости от специфики исследования, в научно-исследовательских институтах, ВУЗах или лабораториях промышленных предприятий. В такой ситуации, будучи непосредственно зависимым от начальства, исследователь очень часто сдерживается или даже подавляется самой бюрократической структурой учреждения или его директором, которые стремятся монополизировать научное открытие или иные результаты исследования ученого для своей личной выгоды или прибыли предприятия.

Мировая история научных открытий переполнена случаями подавления и просто издевательств и насмешек по отношению к реальным ученым-исследователям со стороны их непосредственного начальства и бюрократов, руководивших учреждениями, где эти ученые работали. Таких случаев, иногда закончившихся трагически, — множество: как в прошлом науки так и в настоящем. В том числе, сами результаты оригинального исследования часто губятся преднамеренными искажениями и откровенным плагиатом со стороны недобросовестных, завистливых, и алчных коллег. Такие “коллеги”, будучи не в состоянии сделать что-то новое в науке, пытаются использовать труды своих более талантливых подчиненных, а если это не получается по ряду организационных причин, то просто подавить или не дать ходу этим исследованиям, чтобы эти блестящие научные результаты не оттеняли их собственные бездарные попытки имитации научной деятельности. Эта порочная практика продолжается почти повсеместно и поныне.

Цель этой Декларации состоит в том, чтобы установить фундаментальную доктрину: научное исследование должно быть свободно от скрытого и откровенного репрессивного влияния бюрократических, политических, религиозных и финансовых директив; научное творчество является фундаментальным правом человека не меньше, чем другие фундаментальные права человека. Эта доктрина несомненно должна быть предметом обсуждения международных договоров, и отражена в международном праве.

Главы всех государств и правительств, претендующих на причастность к демократическому мировому сообществу, должны соблюдать и всячески поддерживать эту Декларацию как признак солидарности с заинтересованным международным сообществом ученых, и дать право всем народам нашей планеты Земля к свободному неограниченному научному творчеству на благо всего человечества. Творчество в науке и технике слишком долго были объектом притеснения. Этой порочной практике должен быть положен конец.

Статья 2: Кто такой ученый

Ученый — это любой человек, кто производит научные исследования. Любой человек, кто сотрудничает с ученым в обсуждении и развитии идеи его исследования — также ученый. Проведение формальной квалификации (как-то выдача диплома о специальном образовании, при-

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своение ученой степени и т.п.) — еще не повод для того, чтобы считать кого-то ученым.

Статья 3: Где делается наука

Научное исследование может быть выполнено в любом месте вообще, например, на рабочем месте, в течение формального курса образования, в течение спонсируемой академической программы, в группах, или также индивидуумом у себя дома.

Статья 4: Свобода выбора темы для научного исследования

Многие ученые, работающие по программе получения ученой степени или в рамках других исследовательских программ, в ВУЗах, таких как университеты или колледжи расширенного обучения, не имеют реальной возможности собственного выбора темы их исследовательской работы. Как правило, им предлагается сделать выбор только из некого списка "разрешенных" тем, предоставляемого администрацией или начальством, которое руководит данной программой. Это происходит потому, что академическая иерархия и/или другие академические начальники, администрирующие науку, просто не одобряют самостоятельную линию поведения ученых в науке, боясь что новые оригинальные исследования и возможные неожиданные результаты могут быть намного ярче и успешней их собственной научной деятельности и, таким образом, дискредитировать их собственный авторитет в науке (и, как следствие, они сильно рискуют лишиться получаемых в течении многих лет грантов и другого финансирования, которое может быть передано более успешным ученым). Кроме того, есть риск, что принципиально новые исследования могут опровергнуть какую-либо научную догму, поддерживаемую данной научной школой, что было бы на руку другим научным школам, которые эту догму не признают. Власть ортодоксального большинства, ведомого отнюдь не интересом к поиску новых научных знаний, а элементарными корыстными интересами, жаждой денег и власти, весьма часто срывает научную работу, если становится видна перспектива принципиально нового прорыва в науке. Эта банальная практика — преднамеренное препятствие свободной научной мысли — не имеет ничего общего с наукой, и является преступной. Этой порочной практике должен быть положен конец.

Ученый, работающий для любого ВУЗа, научного института или агентства, должен быть полностью свободен в выборе исследовательской темы. Какие-то ограничения могут происходить только из-за реалий недостаточности материальной поддержки, и ничего более относящегося к собственно теме или предмету научного исследования. Если же ученый выполняет исследование как член рабочей группы, проводящей некоторое исследование по совместной тематике, то выбор должен быть результатом совместных консультаций в данной рабочей группе.

Статья 5: Свобода выбора исследовательских методов

Часто имеет место тот факт, что ученый, проводящий исследование в рамках некоторой академической среды (научного института, ВУЗа или корпорации), вынужден принимать исследовательские методы отличные от тех, которые он избрал в начале своего исследования. Чаще всего это происходит из-за корпоративных предубеждений, навязываемых индивидуалу, а также элементарного лоббирования и корысти получить оплату за аренду оборудования данной лаборатории или института. Эта практика весьма широко распространена, и является по сути преднамеренным препятствием свободы научного творчества. Этой порочной практике должен быть положен конец.

Ученый, работающий по некоммерческой или академической программе, имеет право развивать свою исследовательскую тему любым разумным способом и любыми разумными средствами, которые он считает необходимыми и наиболее эффективными для его исследования. Окончательное решение о том, каким образом и на каком оборудовании будет проводиться данное исследование, должно быть сделано самим ученым.

Если же ученый выполняет исследование в составе рабочей группы, объединенной общей тематикой, руководители проекта имеют право только на консультацию и не должны влиять или ограничивать исследовательские методы или исследовательскую тему ученого в пределах группы.

Научное сообщество — это не армия, а свободное объединение людей, занимающихся научным творчеством на благо человечества и научного прогресса.

Статья 6: Свобода сотрудничества в научном исследовании

Существует немалый элемент конкуренции в практике современной науки. Этому сопутствуют обстоятельства с элементами личной зависти и сохранения репутации академического начальства любой ценой, независимо от научных фактов. Это часто приводит к тому, что ученый, проводящий реальные исследования ведущие к принципиально новым результатам в науке, становится безработным. Эта порочная практика — также преднамеренное препятствование свободе научного прогресса.

Если ученому требуется помощь в исследовании от какого-то другого (любого) человека, который согласен помочь, тогда ученый волен пригласить этого человека для участия в своем исследовании независимо от мнения на эту тему его академического начальства. Ученый также волен предоставлять свою посильную помощь любому другому исследователю, если эта помощь находится в пределах бюджета его исследовательской программы.

Статья 7: Свобода разногласий в научной дискуссии

Вследствие скрытой ревности и жажды личного обогащения, в современном научном сообществе, разделенном корпоративными интересами и закулисной борьбой научных школ, получила широкое распространение ненависть к открытому обсуждению научных результатов а также порочная практика преднамеренно исключать из дискуссии тех ученых, кто подвергает сомнению ортодоксальные догмы, принятые и отстаиваемые той или иной научной школой. Очень часто, ученые способные указать на неточности в текущей теории или интерпретации данных, объявляются сумасшедшими для того, чтобы было удобно игнорировать их мнение и идеи. Они высмеиваются публично и конфиденциально, и систематически получают отказ от научных конференций, семинаров и коллоквиумов так, чтобы препятствовать свободному обсуждению их идей и научных результатов. Преднамеренная фальсификация данных и искажение существующих теорий — теперь частые средства для подавления и скрытия "неугодных" научных фактов. Многие научные комитеты, журналы и академические фонды были сформированы таким образом, чтобы только их руководителям, их помошникам и связанным с ними ученым, им и только им было позволено использовать финансовые ресурсы, публиковать свои научные работы (независимо от качества содержания) и т.п. Эти комитеты часто расходуют огромные суммы денег простых налогоплательщиков, чтобы финансировать исключительно свои собственные проекты, что в конечном итоге ведет к коррупции, обману и лжи. Любое возражение на их проекты, имеющее серьезное научное обоснование, сразу подвергается травле со стороны находящихся под их контролем научных журналов и других средств массовой информации. Единственная цель такой порочной политики — это сделать так, чтобы деньги продолжали по-прежнему течь на банковские счета руководителей этих проектов и их помошников, гарантируя им и членам их семей хорошо обеспеченное будущее, а их друзьям из среды ученых — высоко оплачиваемые рабочие места. Под авторитарным и финансовым давлением этих руководителей, их научные оппоненты увольняются или отстраняются от проведения научных работ и экспертиз, а несогласные ученики отстраняются от PhD программ; на их место назначаются совсем другие люди из числа коррумпированных сообщников. Это все — не наука. Для описания всего этого есть только одно подходящее слово — мафия.

Фундаментальный факт, что никакая научная теория не является абсолютно определенной и неприкосновенной и поэтому открыта для обсуждения и развития, часто игнорируется в академической среде. Также игнорируется тот факт, что одно и тоже явление может иметь несколько равноправных объяснений (как, например, корпускулярная и волновая теория света). Злонамеренно дискредитируется любое объяснение, которое не согласовывается с ортодоксальным мнением, при этом без колебания используются любые ненаучные методы, чтобы одержать верх в дискуссии и получить желаемый грант, субсидию или другую финансовую помощь.

Все ученые должны быть свободны в обсуждении их собственных исследований и исследований других ученых, без опасения публичных насмешек, обвинений, унижений, или необоснованной критики, что совершенно недопустимо в научной дискуссии. Ни один ученый не должен быть поставлен в такое положение, в котором его средства к существованию или репутация будут в опасности вследствие выражения его научного мнения. Свобода научного выражения должна быть главной. Использование административной власти в опровержении научных результатов не имеет ничего общего с нормальным научным процессом и не должно использоваться, чтобы завязывать рот, подавлять, или запугивать ученого. Преднамеренное сокрытие научных фактов и подавление научного мнения — это научное мошенничество, и является составом преступления. Все научные обсуждения экспериментальных или теоретических результатов должны вести к принципу очевидности.

Статья 8: Свобода публикации результатов научного исследования

Цензура научных документов ныне стала стандартной практикой редакций основных научных журналов и электронных архивов. Рецензенты защищены, главным образом, анонимностью так, чтобы автор не смог проверить их предполагаемую экспертизу. Статьи теперь обычно отклоняются, если автор не соглашается или противоречит точке зрения научной школы, которая монополизировала данный научный журнал. Много статей теперь отклоняются автоматически на основании присутствия в списке авторов какого-либо ученого, к которому не расположены редакторы или рецензенты журнала, или который принадлежит к "враждебной" научной школе, придерживающейся иной точки зрения на исследуемое явление природы. Все это не имеет вообще никакого отношения к содержанию поданной научной статьи. Существует также порочная практика составления "черных списков" в которые заносят имена ученых, неугодных данной редакции или рецензентам. Статьи ученых, имена которых занесены в такой "черный список", отклоняются без рассмотрения, по чисто формальным поводам.

Применяющие эту и подобные порочные методы, виновны в подавлении свободного мышления, что является преступлением против прав человека и должно быть осуждено международным научным сообществом.

Все ученые должны иметь право представлять свои научные исследовательские результаты, полностью или частично, на соответствующих научных конференциях и издавать в научных журналах, электронных архивах и любых других средствах массовой информации. Ни один ученый не должен получить отказ в публикации в научном журнале, электронном архиве или других средствах массовой информации, на том основании, что его научно обоснованное мнение или результаты исследования находятся в конфликте с мнением большинства, мнением редакции журнала, или опровергают какую-либо догму, поддерживаемую научной школой, монополизировавшей данный журнал. Ни один ученый не должен быть помещен в "черный список" нежелательных авторов, или блокирован любым другим формальным образом от возможности публиковать результаты своих научных исследований.

Только фактические ошибки в расчетах или эксперименте, или несоответствие тематике данного издания могут быть причиной отказа в публикации поданной научной работы.

Статья 9: Соавторство в научном исследовании

В научных кругах прекрасно известно: многие из соавторов научных публикаций фактически имеют небольшой или вообще никакого вклада в данное исследование. Например, — научные руководители PhD студентов. Во многих таких случаях, человек, который фактически проводит научное исследование и пишет по его результатам научную статью, имеет интеллект и способности, намного выше своего номинального начальника. Тем не менее, номинальные начальники и другие люди, от которых зависит продолжение финансирования научной работы, получение ученой степени, и т.п. чаще всего включаются как соавторы в научную публикацию. Фактические авторы не могут даже возразить против этого, опасаясь что впоследствии могут будут лишены финансирования, возможности получить ученую степень, отстранены от работы в исследовательской группе, и т.п. Известно множество случаев, когда ученые, реально проводившие исследования и писали научные статьи, были вообще исключены их начальством из списка соавторов под угрозой увольнения или прочих репрессивных мер. Эта ужасная практика является преступлением, и не может более продолжаться. Только те люди, кто реально проводил научное исследование, могут быть аккредитованы как соавторы итоговой научной публикации.

Ни один ученый не должен включать другого человека в список соавторов своей научной публикации, если этот человек не внес значительного вклада в данное исследование. Ни один ученый не должен позволять себе быть принужденным любым представителем ВУЗа, корпорации, правительственного агентства или любого другого человека включать их имена в список соавторов исследования, которое они не делали. Ни один ученый не должен позволять использовать свое имя в списке соавторов научной работы как предмет торговли или обмена на любые подарки, ученую степень, или финансовую помощь. Ни один человек не должен стимулировать или пытаться стимулировать ученого в том, что тот включил его в список соавторов научного исследования или публикации, в которую он не внес значительного научного вклада.

Статья 10: Независимость от аффилиации

В настоящее время значительная доля ученых работает по краткосрочным контрактам, тогда как в промежутках между контрактами или грантами (это может длиться годами), они формально не заняты в научной индустрии. В рамках любого контракта существует такое понятие – академическая аффилиация. Вместе с тем, часто политика редакций научных журналов такова, что научные работы исследователей не имеющих академической аффилиации не принимаются к публикации, а часто даже просто не рассматриваются. Кроме того, не имея академической аффилиации, ученый лишен доступа ко многим научным ресурсам, а также возможности представлять свои работы на конференциях. Это — порочная практика, которой должен быть положен конец. Наука не подразумевает наличие академической аффилиации.

Никто, ни одна организация или группа людей администрирующие науку, не должны устанавливать правила препятствующие ученым, не имеющим академической аффилиации, представлять свои научные труды и разработки на конференциях, коллоквиумах или семинарах, а также публиковать их в любых средствах массовой информации. Никто не должен устанавливать правила, препятствующие ученым, не имеющим академической аффилиации, получать свободный доступ к академическим библиотекам или научным публикациям, к посещению научных встреч или лекций в ВУЗах, научных институтах, правительственных или коммерческих лабораториях или любой другой организации.

Статья 11: Открытый доступ к научной информации

Специализированная научная литература и подавляющее большинство научных журналов дают очень маленькую прибыль или вообще убыточны. Поэтому издатели не желают издавать их на коммерческой основе и, естественно, требуют от ученых денег. Оплата такой литературы, чаще всего, поступает от исследовательских институтов, где работают данные ученые, а также ВУЗов, академических фондов и организаций, филантроповиндивидуалов и т.п. При таких обстоятельствах коммерческие издатели должны предоставлять свободный доступ к электронным версиям публикаций и по возможности стремиться свести стоимость напечатанных материалов к минимуму.

Все ученые должны способствовать и стремиться к тому, чтобы их публикации и исследовательские документы были доступны международному научному сообществу бесплатно, или в альтернативе, если этого нельзя избежать, по минимальной стоимости. Все ученые должны предпринять активные меры для того, чтобы сделать их книги и журналы доступными по самой низкой возможной цене так, чтобы научная информация могла быть доступна самому широкому международному научному сообществу.

Статья 12: Морально-этическая ответственность ученого

История свидетельствует: в конечном счете научные открытия очень часто используются в разрушительных целях, во вред и даже уничтожение цивилизации и человечества в целом. Так как научно-технический прогресс не может быть остановлен, необходимо установить ряд средств, препятствующих такому деструктивному применению результатов научных исследований и технических разработок. Прежде всего, необходимо помнить: только демократически избранное гражданское правительство, свободное от религиозных, расовых и других предрассудков, может сохранить цивилизацию. Только демократически избранные правительства и комитеты могут сохранить право на свободное научное творчество. Ныне мы видим: различные недемократические государства и тоталитарные режимы проводят активные исследования и технические разработки в ядерной физике, химии, вирусологии, генной инженерии и т.п., с целью производства ядерного, химического и биологического оружия массового поражения. Ни один ученый не должен добровольно сотрудничать с недемократическими правительствами или тоталитарными режимами. Если же ученый был силой привлечен к работам по созданию вооружений в таком государстве, он должен постараться найти способы замедлить продвижение своей исследовательской программы в этой области так, чтобы данный тоталитарный режим не смог воспользоваться полученными результатами его исследования и цивилизованные страны, несущие всему миру принципы демократии и прогресса, смогли бы в конечном счете победить тоталитарное зло.

Все ученые несут моральную ответственность за результаты их научных работ и открытий. Ни один ученый не должен добровольно участвовать в проектировании или создании оружия любого вида для недемократических государств или тоталитарных режимов, или позволять применить его знания или научные навыки к развитию технологий, опасных для человечества. Каждый ученый должен иметь в виду, что деятельность любого недемократического правительства, а также нарушение прав человека являются преступлением.

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