ASTRONOMY

The Galactic Red Shift

The recent development of the technique of resonant scattering of γ-rays, using the Mössbauer effect, appears to raise the possibility of a terrestrial test of one theory of the red shift observed by Hubble in the light coming from distant galaxies.

The usual interpretation of the galactic red shift is that it is a Doppler effect due to mutual recession of the centres of the galaxies; there are, however, other possible interpretations, and among these is the suggestion by Finlay-Freundlich[1] that it is due to loss of energy by light in passage through a radiation field. Finlay-Freundlich was led to this conclusion from a study of stellar red shifts and put forward the empirical relation that the fractional energy loss is proportional to the path-length and the fourth power of the temperature (energy density) of the radiation field. With this simple empirical relation and using the observed stellar and galactic red shifts, he deduced a value for the average intergalactic (radiation) temperature which does not seem unreasonable on general thermodynamic grounds.

Born[2] pointed out that Finlay-Freundlich's empirical relation might correspond to an otherwise unknown photon–photon interaction in which loss of energy occurs without change in direction of the photon. Born showed that there was some evidence in the empirical relation for a fundamental length which ought perhaps to be part of a general description of the radiation field, and suggested that the energy apparently lost might reappear as radio emission.

These suggestions by Finlay-Freundlich and Born, if correct, would have very far-reaching consequences in cosmology and in the field theory of elementary particles. However, several authors[3] have directed attention to certain difficulties. Among other points, it is asserted that the observed stellar radio emission and the change in red shift of binary stars in eclipse are too small to be consistent with the proposed theory. Some of these difficulties may be very real, but bearing in mind the experimental difficulties in measuring stellar red shifts, the variety of causes which can result in both red and blue shifts, and that an otherwise unknown photon–photon interaction could result in the appearance of an entirely unknown particle, it seems worth considering the possibility of a terrestrial experiment under controlled conditions.

At present, attempts are being made at Harwell and elsewhere to observe the gravitational red shift using γ-rays from iron-57 and the Mössbauer effect. The resolution using iron-57 is $\sim 6 \times 10^{-13}$. It is easy to show that if the γ-rays in these experiments were allowed to pass through a radiation field of similar quality and the same order in energy density as on the surface of the Sun, extending over a distance of about a metre, the red shift expected from Finlay-Freundlich's relation is about 1 per cent of the resolution. 1 per cent is not far from the expected gravitational red shifts in the present experiments in which the photons fall considerably larger distances. In a practical attempt to test Finlay-Freundlich's relation, it would probably be necessary to have a radiation density times path-length such that the expected shift would be of the same order as the resolution; and although this would require a considerable effort, it does not seem entirely beyond present pulse techniques such as are used in thermonuclear work, but in this case involving lower plasma temperatures. It should be a reasonably fair test if most of the energy in the radiation field lies in or near the visible region, and if the dependence on energy of the incident photon in Hubble's law can be regarded as sufficiently well established.

A negative result for this proposed experiment would serve the useful purpose of removing one theory of the galactic red shift. At present it would be idle to pursue in detail the various possible interpretations of an unambiguous positive result, but it may be of interest to outline one of these briefly and simply here.

If we can regard our Sun as typical of about 10^{11} stars in a typical galaxy and use a value of $\sim 2 \times 10^{6}$ light years as the average intergalactic distance, it is easily shown that the average rate R_1 of release of radiation into unit volume of intergalactic space is $\sim 3 \times 10^{-29}$ erg/c.c./sec. The average rate R_2 of apparent loss of energy by photons in the galactic red shift is $K\rho$, where K is Hubble's empirical constant and ρ is the average energy density of radiation in intergalactic space. Using a value for K of 5×10^{-18} sec.$^{-1}$ and for ρ of $\sim 6 \times 10^{-12}$ erg/c.c., it is clear that $R_1 \sim R_2$. Confirmation of Finlay-Freundlich's relation would justify this value of ρ and also the qualitative interpretation $R_2 = K\rho$. In these circumstances the galactic red shift becomes a vast sink which receives the radiation from the stars and transforms it into some other form, the processes involved being in approximate equilibrium at present. It does not seem entirely inconceivable that at least some of the energy thus transformed might reappear eventually in space as neutrons by a net reaction involving unknown particles. The hydrogen from the neutron decay would provide fuel for new stars as in Hoyle's theory of continuous creation. The net effect of the entire process would be to slow up what seems at present an inevitable decline towards a universe of black dwarfs, photons and neutrinos as the hydrogen in the stars is steadily transformed to helium photons and neutrinos. The amount of recycling of hydrogen by such a hypothetical process could be quite large, as most of the energy released in the net reactions in the stars goes to the photons which escape from the stellar surfaces. Approximate equilibrium at present need not conflict, at least qualitatively, with the recent results of Ryle, if a 'beginning' consisting of a vast hydrogenous cloud is assumed, for in the early stages of condensation the low value of ρ would correspond now to an apparent increase in the frequency of observation of low-intensity (assumed distant) sources.

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[2] Born, M., *Proc. Phys. Soc.*, A, **67**, 193 (1954).

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OCEANOGRAPHY

Ultra-violet Absorption of Sea Water

It has been shown that at wave-lengths less than 230 mμ., the absorbency of sea water is about double that of a solution containing the same concentration of inorganic salts[1,2]. We ascribe the difference to the