Department of Mechanics

KTH, S-100 44 Stockholm, Sweden

Activity Report 1997

Contents

Preface

This report was compiled from many bits and pieces of information. Thanks are due to all contributors. It reflects the activities of the fifth budget year of the (new) department of mechanics in education, research and other areas.

Stockholm, August 1998

Arne Johansson, department chairman
Martin Lesser, department vice chairman

1 Introduction

This is the fifth annual activity report of the new mechanics department and because of the change in budget periods, it covers the year 1997. The mechanics department (web address: http://www.mech.kth.se) has (approximately) 78 employees and a yearly turnaround of nearly 38 MSEK. It is also host department for the Faxén Laboratory, a NUTEK competence centre for the fluid dynamics of industrial processes.

The head of department ('prefekt') is professor Arne Johansson and vice *dito* ('proprefekt') is professor Martin Lesser. The study rector ('studierektor') is Hanno Essén.

The department board for the period until June 30, 1997 consisted of: Henrik Alfredsson, Fritz Bark, Hanno Essén, Arne Johansson (chairman), Lillemor Lindbom, Anders Nilsson (prof. of technical acoustics, external board member), Daniel Söderberg (grad. stud. repr.), Lars Thor and an undergraduate student representative.

The new department board for the period July 1, 1997 to June 30, 2001 consists of: Gustav Amberg, Fritz Bark, Arne Johansson (chairman), Martin Lesser, Lars Thor, Ingunn Wester, Bo Norman (prof. Dept of Paper and Pulp Technology, external board member), Daniel Söderberg (grad. stud. repr.) and an undergraduate student representative.

The teaching activities comprise courses in basic mechanics at all parts of KTH except the Schools of Architecture and Surveying, and a large number of higher level and graduate courses on many different aspects of mechanics of solids as well as of fluids.

The research activities can essentially be classified into two major areas, *viz.* "Fluid mechanics" and "Theoretical and applied mechanics". In December 1997 there were altogether 48 graduate students active at the department (18 of which are associated with the Faxén Laboratory) and 12 external graduate students in industry and research institutes. Five doctoral degrees and five licentiate degrees were awarded during 1997.

The Mechanics department together with fluid dynamics researchers at other KTH departments and at FFA earlier received the status of Swedish ERCOFTAC Pilot Centre (coordinator: Dan Henningson). A number of new partners from the different Nordic countries have joined the centre, which now has the status as Nordic ERCOFTAC Pilot Centre.

The Faxén Laboratory was formally started July 1995 and is directed by Professor Fritz Bark. The centre comprises activities at four different KTH departments ('Kemiteknik', 'Materialens Processteknologi', 'Mekanik', 'Pappers- och Massateknik') and 19 industrial partners. The activities is divided into three program areas:

- Electrochemistry
- Material process technology
- Paper technology

Altogether 18 doctoral students are active in the program activities (for details see section 9).

Personel related matters

13 new graduate students started during 1997.

Dr Erik Lindborg started as research associate ('forskarassistent') in April 1997.

Dr Harry Dankowicz started as research associate ('forskarassistent') in December 1997.

Department meetings and miscellaneous

The department board met on February 20 and May 21, 1997.

A department meeting with Christmas dinner (in Japanese style) was held December 11–12, 1997 at Hasseludden.

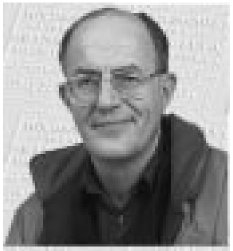
A 'samverkansgrupp' consisting of Arne Johansson (chairman) and Ingunn Wester as representatives for the employer, and three representatives for the employee organizations, *viz.* Marcus Gällstedt (SF), Lillemor Lindbom (ATF) (until April), Lars Bjernerstam (ATF) (from May) and Anders Thor (SACO) has been active. The tasks include, *e.g.* MBL negotiations. Also present during the meetings has been Karl-Erik Thylwe ('skyddsombud').

The department has a contract one hour per week at 'KTH-hallen' for 'innebandy' or volleyball.

2 Personnel

Professors

Henrik Alfredsson, PhD in mechanics, KTH 1983 and Docent there 1985. At KTH since 1977. Extra professor 1986 and professor in Fluid Physics 1989. Research in fluid mechanics, in particular laminar-turbulent transition.



Fritz Bark, Ph.D. in Applied Mechanics at KTH 1974. Extra professor in Applied Mechanics 1979, professor in Hydromechanics, 1985, all at KTH. Research in fluid mechanics, in particular convection in electrochemical systems and processes in paper technology. Director of the Faxén Laboratory.

Arne Johansson, PhD in mechanics, KTH 1983 and Docent there 1984. At KTH since 1977. Extra professor 1986 and professor in mechanics 1991. Research in fluid mechanics, in particular turbulence and turbulence modelling. Department chairman.

Martin Lesser, Ph.D in Aerosp. Eng. 1966 at Cornell; Bell Labs 1966–71; Inst. Cerac in Lausanne 1971–75; 1975–84 docent and prof. at LuTH; 1984–87 Chairman and full prof. at Dept of Mech. Eng. & Appl. Mech. at Univ. of Penn.; 1987 professor in Mechanics at KTH; research on multibody mechanical systems and the use of computer algebra in mechanics. Department vice chairman.

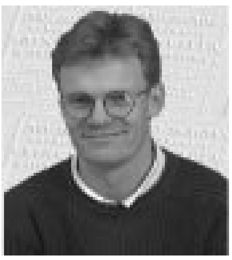
‘Biträdande, gäst- resp. adjungerad professor’

Bengt Enflo, PhD and Docent 1965 in theoretical physics, Univ. of Stockholm. Two years at Nordita and one year at CERN. ‘Biträdande professor’ at KTH since 1996. Research in theoretical acoustics, nonlinear waves, acoustic diffraction. ’Biträdande professor’ since 1996

Laszlo Fuchs. Ph.D. in Gasdynamics KTH 1977, Docent KTH 1980. Adj. prof. Applied CFD (50 %), KTH 1989–1994 IBM Sweden (50 %) 1989-1992. Prof. Fluid Mechanics LTH 1994–. Guest Prof. (30%) at the Mechanics Dept, KTH 1994– Research in CFD methods and models, with application to compressible flows and combustion in engines and furnaces.

Dan Henningson. M.Eng. MIT 1985, Ph.D. KTH 1988, Docent KTH 1992, Ass. Prof. Appl. Math. MIT 1988-1992. Adj. Prof. Mechanics (20 %) KTH 1992-. Research on linear and non-linear hydrodynamic stability and numerical simulation of transitional flows.

Senior Lecturers (in Swedish: universitetslektorer)



Gustav Amberg, PhD in fluid mechanics, KTH 1986, Docent at KTH 1990. At KTH since 1982. Research in fluid mechanics and heat and mass transfer, in particular with application to materials processes.

Nicholas Apazidis, PhD in mechanics, KTH 1985, Docent at KTH 1994. At KTH since 1977. Research in two-phase flow and shock wave focusing in fluids.

Anthony Burden, PhD in applied mathematical physics, Univ. of Göteborg 1984. Research on two-point closures for turbulence and computational models for turbulent combustion.

Ian Cohen, PhD and Docent 1982 in theoretical physics,
Univ. of Stockholm. Research in general relativity and computer algebra applications in physics.

Anders Dahlkild, PhD in mechanics 1988 and Docent 1992 at KTH. Research on two-phase flow. Scientific secretary of the Faxén Laboratory.

Hanno Essén, PhD in theoretical physics Univ. of Stockholm 1979. Three years in England and Canada. Docent 1986. At KTH since 1988. Research on general relativity and on non-holonomic systems.

Richard Hsieh, PhD in mechanics and docent at KTH.

Arne Karlsson, TeknL.

Göran Karlsson, PhD in quantum chemistry 1970 Univ. of Uppsala. Canada and US 1971. At KTH since 1973. Research on education didactics, computer aided learning, distance eduction, computer information systems.

Christer Nyberg, PhD in mechanics 1979 KTH. Research in acoustics.

Lars Söderholm, PhD and Docent 1970 in theoretical physics, Univ. of Stockholm. Two years at Nordita. At KTH since 1980. Research on relativity and continuum mechanics: Klein-Alfvén cosmology, relativistic temperature, material frame indifference, constitutive relations and kinetic theory.

Anders J Thor. TeknL in mechanics, KTH 1964. At KTH since 1956. Work on standards for quantities and units.

Lars Thor, PhD in mechanics at KTH 1973. At KTH since 1965. One semester of teching in Australia 1990.

Karl-Erik Thylwe, PhD 1981 in theoretical physics, Univ. of Uppsala. Four years at Univ. of Kaiserslautern and Manchester. Docent 1987. At KTH since 1988. Research on Regge-pole theory and semi-classical phenomena of atom-molecule collisions, nonlinear phenomena of dynamical systems, asymptotic methods.

Lecturers and researcher (in Swedish: universitetsadjunkter and 1:e fo.ing.)

Gunnar Maxe

Pär Ekstrand, Responsible for the department's computer system

Nils Tillmark, TeknD, Responsible for the department's lab. facilities

Research associates (in Swedish: forskarassistenter)

Per Dahlqvist, PhD in Theoretical physics at the University of Lund 1989, Docent in theoretical physics, KTH 1995. At KTH since 1991. Research in classical and quantum chaos.

Harry Dankowicz, PhD at Cornell Univ. 1995. Academic year 1994/95. Göran Gustafsson's Postdoctoral Fellowship during 1995/96. Research in modern mechanics of complex systems, and theory of friction.

Magnus Hallbäck, PhD in Fluid Mechanics, KTH 1993. At the Department until April 1997. Now at ABB Corporate Research.

Barbro M. Klingmann, PhD in Fluid Physics, KTH 1991. Postdoc at EPFL Lausanne and Novosibirsk 1992-94 and at Volvo Aero. 1994-1996. Research on transition and turbulent separation.

Erik Lindborg, TeknD KTH 1996, Research in turbulence.

Arne Nordmark. PhD in mechanics 1992. At KTH since 1984. Research in the dynamics of mechanical systems with discontinuous or impulsive forces.

Technical and administrative staff (in Swedish: TA-personal)

Lars Bjernerstam

Catrin Engelstrand

Marie Eriksson (at the department until Oct. 1997)

Marcus Gällstedt

Ulf Landén (50 %)

Lillemor Lindbom (intendent)

Anne-Mari Olofsson

Jan Ströman

Ingunn Wester (intendent)

Professors emeritii

Bengt-Joel Andersson
Sune Berndt
Olof Brulin
Stig Hjalmars

Graduate students (in Swedish: doktorander)

Jesper Adolfsson
Krister Alvelius
Paul Andersson (also at FFA)
Gerald Audenis (FLA)
Stellan Berlin
Gitte Ekdahl
Per Elofsson
Jerome Ferrari (FLA)
Mats Fredriksson
Franck Gregoire
Jonas Gunnarsson (FLA)
Francois Gurniki (FLA)
Torkel Hambreus (also at FFA)
Casper Hildings (also at FFA)
Carl Häggmark
Marcus Högberg
Nulifer Ipek (FLA)
Bo Johansson
Jukka Komminaho
Renaud Lavalley
Anders Lennartsson
Mats Lind (FLA)
Björn Lindgren
Nicholas Moch (FLA)
Pedro Olivas (FLA)
Magnus Olsson
Per Olsson
Mehran Parsheh (FLA)
Ivan Pavlov
Henrik Sandqvist
Torbjörn Sjögren
Mikael Sima
Martin Skote
Lars-Göran Sundström
Daniel Söderberg (FLA)
Robert Tönhardt
Ruben Wedin (FLA)
Johan Westin
Ola Widlund (FLA)
Petra Wikström
Christian Winkler
Naoki Yoshida

Sima Zahrai (FLA)
Jens Österlund

External graduate students (not employed by department of mechanics)
Leonard Borgström, Alfa Laval, Tumba
Jan Eriksson, Vattenfall in Älvkarleby
Koji Fukagata (FLA) ABB Corp. Res.
Jan-Erik Gustafsson, STFI
Tor-Arne Grönland, FFA
Hans Moberg, Alfa Laval, Tumba
Hans Mårtensson. Volvo Aero Corporation in Trollhättan.
Roland Rydén. Volvo Aero Corporation in Trollhättan.
Lars Thysell, FFA
Stefan Wallin, FFA

The graduate students with (FLA) after their names are associated with the Faxén Laboratory. Five other graduate students are associated with FLA but employed at other departments at KTH (see section 9).

3 Laboratory facilities, computers

3.1 Laboratory facilities

3.1.1 Wind tunnels

The department has a laboratory with several permanent experimental facilities.

- MTL subsonic windtunnel, 7 m long (1.2 m × 0.8 m) test section, max. speed 69 m/s
- Subsonic wind-tunnel, 0.4 m × 0.5 m test section, max. speed 50 m/s
- Shock tube for research and student laboratory exercises

A major facility is the MTL wind-tunnel, which is a low-turbulence wind-tunnel with outstanding flow quality - the turbulence level is as low as 0.02 %. It is used for a variety of long-term research projects on turbulence and laminar-turbulent transition, flow separtion and turbulence structure.

The department also has access to a continuously running supersonic wind-tunnel, 0.1m×0.1m test section, with 'continuously' variable Mach number (0.7–2.5), which is stationed at the Department of Energy Technology, KTH.

3.1.2 Other flow facilities

There are also a number of smaller experimental apparata for research and student demonstration purposes:

- miniature convection cell for study of thermocapillary convection
- model of a headbox for distribution of fiber suspension in paper manufacturing applications
- plane Couette flow apparatus with and without system rotation
- curved or straight rotating channel flow apparatus for studies of instabilities due to centrifugal and rotational effects
- plane Poiseuille flow apparatus (2m×0.8m) for transition studies
- a small water table for student demonstrations
- Hele-Shaw cell and Taylor-Couette apparatus
- a pipe-flow facility for student exercises

3.1.3 Measurement equipment

The PIV system purchased by the Department of Mechanics consists of a Nd:YAG double pulse laser, a high resolution CCD camera capable of storing two consecutive frames at a time separtion of 1 ms, and a processing unit for crosscorrelation of the two images. The system (laser and camera) will run at a frequency of 15 Hz.

The department has two equipments for Laser-Doppler Velocimetry (LDV). One of the LDV systems was acquired during 92/93 and is a two-component fibreoptic system from Aerometrics, with a high power Ar laser. An other system is a low energy fiberoptic one-component "FlowLite" system, recently purchased from Dantec, which is easy to use and to adapt to different measurement situations, including student excercises.

Hot wire techniques are extensively used and constantly developed at the laboratory. Many different types of probes are designed and made 'in-house'. The smallest wires used have a diameter of 0.6μm and a typical length of 0.1 mm. Data sampling is carried out mainly with Macintosh computers.

3.1.4 Other laboratory equipment

The laboratory also has some equipment for flow visualisation

- Schlieren system with possibility for short duration double flash exposure
- High speed camera (up to 500 frames per second) for flow visualisation
- Smoke generator for flow visualisation

3.2 Computers

The department has a computer system consisting of 35 SUN workstations running Solaris 2.5.1, 12 IBM-RS6000 workstations running AIX 4.2, 7 X-terminals, (>)30 Macintosh computers and (>)20 PC's running Windows 95/NT or Linux. Pär Ekstrand (pe@mech.kth.se) is responsible for the computers, with help from Arne Nordmark and Anders Lennartsson. Jesper Adolfsson has revised the departments web pages and are responsible for maintaining them.

The system is mainly managed by three servers. A SUN sparc 4 called eiger for central services like mail, printers and DNS. The department has its own AFS cell and Kerberos realm. There is 36 GB of disk storage in the AFS filesystem distributed on four 9GB disks with separate wide SCSI controlers for each disk. The disks are placed on two dedicated AFS file servers, a SUN sparc 10 called pollux and a SUN sparc 20 called castor. Both fileservers are dual processor machines. There is an aditional dedicated WWW and FTP server, a SUN Spark 5 called nadelhorn.

A PC called vulcan running Linux has been set up as a small modem service with four modems currently connected.

The department has four IBM-RS6000 workstations serving as numbercrushers, a model 590, a model 390, a model 375 and a model 370. They are setup in a DQS batch system. They where acquired 93-95 with grants from the Göran Gustafsson Foundation.

There are also two SUN Ultra2's, called dom and ask, shared by the department for interactive jobs.

A significant amount of computer time has also been granted to some of the research groups within the department from the national supercomputer centers NSC and PDC. The department is also part of the KALLSUP consortium with a CRAY J90 computer with 32 processors. The latter has served as a major number crunching machine for the department's activities in the area of direct numerical simulation of turbulent flows.

The department has signed a license agreement for Microsoft software as a part of a central agreement between KTH and Microsoft. It implies that we will have a continuous supply of upgrades, new versions etc of, *e.g.* Word and Excel. Also manuals will be supplied through this agreement (contact person: Lars Thor). The department also has licenses for a number of other softwares products.

4 Economy

A brief overview of the different categories of incoming resources to the department is given below for 1997. The incoming resources to the Faxén Laboratory are not included here. These amount to roughly 8 MSEK for 1997 (excluding in-kind contributions). The Faxén Laboratory is described separately in section 9.

INCOME

	Dept. total
Education (GRU)	**10.4**
Research (FOFU)	**15.1**
External	**12.2**
——	——
Σ	**37.7**

The external funding is mainly composed of grants from TFR, NUTEK, The Göran Gustafsson Foundation and NFR. The total of 37.7 MSEK for 1997 may be compared with a total of 41.9 Mkr for the period July 1 1995 – December 31 1996, which divided by 1.5 gives a total of 27.9 MSEK per 12 month period.

5 Teaching activities

5.1 Undergraduate courses

In most schools we use the textbook by Meriam and Kraige in the basic and continuation courses in the first and second year respectively. The textbook by Thor-Höglund is used in the schools E and B. The continuation course in F uses Fowles and Cassiday (Analytical mechanics). The teachers are not completely happy with Meriam and Kraige so course notes and handout materials are also used.

Several teachers meetings were held and pedagogical methods and problems were discussed. Mandatory home assignment problems are included as part of the requirements for almost all of the courses in addition to the written exams. The performance of the students vary a lot but the home assignments, as well as mid-course exams, ensure that the students work continuously during the course.

The basic course in mechanics was also given as a summer course.

The following is a list of undergraduate courses given during 96/97, here given with Swedish names (english translations given within parenthesis).

Grundkurser (basic courses)

Studieinriktn. *School*	*Läsår* *Year*	*Nummer* *Course no.*	*Poäng* *Credit*	*Namn* *Name*
B,I,M,T	1	5C1103	6	Mekanik, baskurs (Mech. basic course)
V,E,F	1	5C1103	6	Mekanik, baskurs (Mech. basic course)
K,D	1	5C1102	4	Mekanik, mindre kurs (Mech. shorter course)
M	1	5A1224	4(av 11)	Klassisk fysik, komplettering (Classical physics)
T	2	5C1111	4	Mekanik, fortsättningskurs T (Advanced mech. for T)
M	2	5C1112	4	Mekanik, fortsättningskurs M (Advanced mech. for M)
F	2	5C1113	4	Mekanik, fortsättningskurs F (Advanced mech. for F)
V	2	5C1114	4	Mekanik, fortsättningskurs V (Advanced mech. for V)
T	2	5C1201	8	Strömningslära med termodynamik (Fluid mechanics with thermodynamics)
F	3	5C1202	4	Strömningsmekanik inledande kurs (Fluid Mechanics, Introductory Course)
F, M, T	3	5C1203	5	Strömningsmekanik, ak (Fluid Mechanics, General Course)
F, M, T	3-4	5C1204	6	Strömningsmekanik, stk, del 1 (Fluid Mechanics, Advanced Course, part 1)
F, M, T	4	5C1205	4	Kompressibel strömning, ak, (Compressible flow, general course)
F, M, T	4	5C1206	6	Kompressibel strömning, stk del 1, (Compressible flow, advanced course part 1)
M	3	5C1921	4,5	Teknisk strömningslära (Technical fluid mechanics)

Högre kurser (advanced courses)

Studieinriktn. *School*	*Läsår* *Year*	*Nummer* *Course no.*	*Poäng* *Credit*	*Namn* *Name*
MMT	3	5C1121	4	Analytisk mekanik (Analytical mechanics)
F, M, T	4	5C1122	4	Kontinuummekanik (Continuum mechanics)
F, M, T	4	5C1123	4	Mekanikens matematiska metoder, ak (Math. methods of mech., general course)
F, M, T	4	5C1124	6	Mekanikens matematiska metoder, stk (Math. methods of mech., advanced course)
F, M, T	4	5C1980	4	Mekanikens tillämpningar (The applications of mechanics)
F, M, T	4	5C1400	5	Ickelinjär dynamik i mekaniken Non-linear dynamics in mechanics
F, M, T	4	5C1902	4	Advanced dynamics of complex systems
F, M, T	4	5C1904	4	Advanced modern mechanics
F, M, T	3-4	5C1204	6	Strömningsmekanik, stk, del 2 (Fluid Mechanics, Advanced Course, part 2)
F, M, T	4	5C1206	6	Kompressibel strömning, stk del 2, (Compressible flow, advanced course part 2)
F, M, T	4	5C1207	5	Gränsskiktsteori och termisk konvektion (Boundary Layer Theory and Thermal Convection)
F, M, T	4	5C1940	4	Numerisk strömningsmekanik (Numerical fluid mechanics)
F, M, T	4	5C1965	3,5	Experimentella metoder inom strömningsmekaniken (Experimental methods in fluid mechanics)
F, M, T	4	5C1992	4,5	Turbulens (Turbulence)

5.2 Graduate courses

Fluid dynamics courses:

The courses Boundary Layers and Thermal Convection in Fluid Mechanics (G. Amberg, D. Henningson and A. Johansson), Experimental methods in fluid mechanics (H. Alfredsson and A. Johansson), Numerical Methods in Fluid Mechanics (L. Fuchs) and Turbulence (A. Burden and A. Johansson) were also given with extensions as graduate courses (course numbers: 5C5118 5 p, 5C5039 5 p, 5C5114 5 p and 5C5112 6 p, respectively).

– Fluid Mechanics, Advanced Course (5C5105 10 p) was given by G. Amberg, A. Dahlkild, A. Johansson och L. Söderholm.

Theoretical and applied mechanics courses:

– Modern analytical mechanics (5C5001 8 p) was given by H. Dankowicz
– Non-linear oscillations and dynamical systems (5C5045 5 p) was given by A. Nordmark
– Perturbation methods in mechanics (5C5108 4 p) was given by K.-E. Thylwe

5.3 Master theses ('examensarbeten')

Advisors are given within parenthesis.

970224 Bindzau, Thomas (with Niklas Lind), Solving the Survivable Network Design Problem Using a Two-species Genetic Algorithm (H. Essén, R. Lindgren)

970224 Lind, Niklas (with Thomas Bindzau), Solving the Survivable Network Design Problem Using a Two-species Genetic Algorithm (H. Essén, R. Lindgren)

970618 Johansson, Bo, On Generation of Polygonal-Shaped Shock Waves – Experimental Studies (N. Apazidis)

970623 Hamrin, Mats, Development of an Aircraft Simulation Programme (H. Essén, R. Lindgren)

970626 Ekdahl, Gitte, The Mechanics of Overhead Railroad Electrification Systems, TRITA-MEK 97-15 (M. Lesser)

970915 Tehranian, Shahram, Flameholding Configurations for Kerosene Combustion in a Mach 1.8 Airflow, TRITA-MEK 97-18 (A. Johansson)

971215 Holm, Richard A Study of the Feasibility of Using Existing Pressure Difference in a Wind Tunnel with a Choked Section For Intake Air Extraction at Low Mach Number (A. Johansson)

6 Research areas – short project descriptions

Short descriptions of on-going research projects are given below. The publication numbers refer to section 7.5.

6.1 Theoretical and applied mechanics

Shock wave propagation in fluids

Researchers: Nicholas Apazidis, Martin Lesser, Graduate student: Bo Johansson

Sponsors: TFR.

This project deals with propagation of shock waves in liquids and liquid impact problems. Generation, reflection and convergence of shock waves in confined chambers of various forms is investigated on the basis of Whitham's non-linear theory of geometrical shock dynamics. This theory has been extended by a new theoretical and computational method, developed by Apazidis & Lesser (1996). The method can be applied to the propagation of shocks arbitrary in strength and form into a medium with no-homogeneous flow conditions.

Calculations based on the new approach have been applied to the problems of shock reflection and convergence in various types of confined chambers. It is shown that by an appropriate choice of the form of the reflector boundary one may obtain reflected shock waves having desirable shapes, for example a near-square shape. Also reflectors with parabolic geometry are considered. A cylindrical wave is generated at the focus of the parabolic cross-section. It is shown that contrary to the linear case the reflected wave is no longer planar. Experimental investigations of shock focusing in a thin confined chamber with a reflector boundary in the form of a slightly perturbed circle have been carried out. Experimental results confirm the possibility of producing polygonally-shaped converging shocks.

Technological and medical applications of the project may be found within the fields of shock wave propagation, shock induced collapse of cavities, erosion, disintegration of kidney and bladder stones by means of a shock wave attenuation in lithotriptor devices.

Publications: 58

Chaotic systems and their quantization

Researchers: Per Dahlqvist

Sponsor: NFR

Chaotic systems and their quantum counterparts are studied. Classical and semiclassical properties are studied in a unified formalism involving concepts such as dynamical zeta functions, evolution operators and periodic orbits. The emphasis is on bound systems exhibiting intermittency. Classically, computation of properties like Lyapunov exponents, decay of correlations and diffusion rates are considered. Semiclassically, the accuracy of quantization schemes for chaos and the limitations of suggested universal properties are studied.

Publications: 4,5,6,7,8,48,49

Human and machine locomotion

Researchers: Harry Dankowicz, Jesper Adolfsson, Arne Nordmark, Anders Lennartsson

Sponsor: TFR

The inherent dynamics of a bipedal, kneed mechanism are studied with particular emphasis on the existence of stable three-dimensional gait in the absence of external, actively regulated, control. Suitable modifications of geometry and mass distributions are suggested to afford implementation of walking in complicated and potentially changing terrain.

Originating in the pioneering work by McGeer and others, the approach is based on the assumption that satisfactory walking motion under actuation can be achieved more efficiently once the mechanism's natural dynamics have been accounted for. Thus, the need for actuation is minimized by controlling the system about a motion dynamically achievable by the passive system, rather than imposing a behavior far from such a motion.

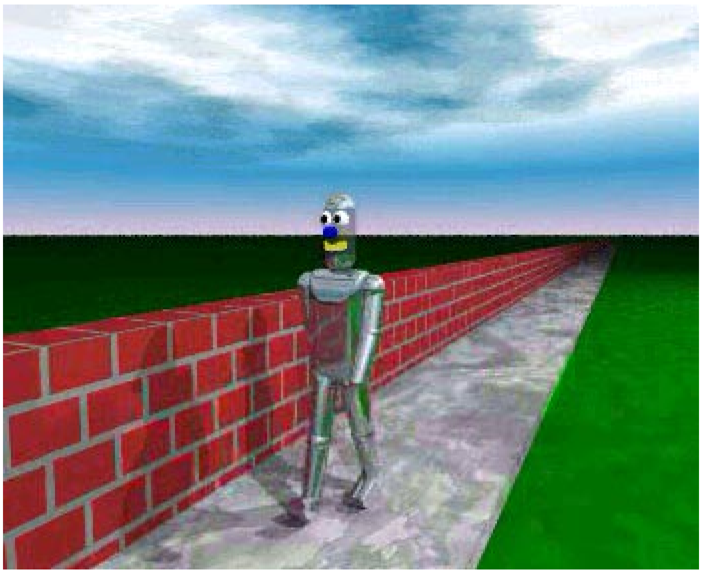


Figure 1: A simulated twolegged walking robot

Dynamics of Hamiltonian systems with applications to celestial mechanics

Researcher: Harry Dankowicz

Sponsor: TFR

The geometry of certain higher-degree-of-freedom Hamiltonian systems allows for a perturbation approach to the study of stochasticity and chaotic behavior, such as sensitive dependence on initial conditions and diffusion in phase space. In particular, the motion of small grains in the vicinity of asteroids and the rings of the greater planets falls into this category. We study the global structure of phase space and obtain measures for characteristic escape rates of the grains from the asteroids.

Publications: 9,10,12

Dynamical models of friction

Researchers: Harry Dankowicz, Arne Nordmark

Sponsor: TFR

We develop models of friction which incorporate dynamical, inertial type effects as well as history dependency, such as hysteresis. These are simulated for comparison with actual experiments. The models are further studied with particular emphasis on bifurcation behavior associated with the appearance of stick-slip oscillations. Such oscillations turn out to be associated with the crossing of a discontinuity surface across which the vector field has a discontinuous derivative. Their appearance is thus closely related to the phenomena connected with grazing bifurcations for impact oscillators. The corresponding theory is applied to explain pertinent features of the stick-slip bifurcations.

Publications: 11

Formulations in the analysis of multibody mechanisms

Researcher: Harry Dankowicz

Sponsor: TFR

We study a method for the successive imposition of constraints on a free particle mechanism and the subsequent derivation of closed sets of differential equations for the evolution of the mechanism with time. Fundamental is the idea of ideal constraints as contained in the d'Alembert principle.

Propagation and diffraction of sound in fluids

Researchers: Bengt Enflo, Claes Hedberg (University of Karlskrona/Ronneby)

Sponsor: TFR

In the project basic problems of nonlinear acoustic wave propagation are studied. Burgers' equation and its generalizations are studied by analytical and numerical methods. Applications are found to propagation of shocks and signals in the sea and in the atmosphere. Examples of problems studied by use of equations of Burgers' type are: studying the decay of plane wave pulses with complicated structure, finding asymptotic waveforms originating from spherical and cylindrical sine waves and short pulses, nonlinear acoustic wave propagation in dispersive and layered media and design of effective shock pulses in sound beams.

Publications: 31,32,56

Theoretical investigations of underwater sound

Researchers: Bengt Enflo, Graduate student: Henrik Sandqvist

Sponsor: TFR

The project is to study theoretically the propagation of underwater sound under conditions similar to those occurring in realistic applications. That means that refraction and the stratification of the medium are taken into account. Nonlinear effects are taken into account: low frequency narrow beams are assumed to be produced by nonlinear interaction of fundamental monochromatic waves (so called parametric radiators). Attempts are made to find, numerically and analytically, solutions of generalizations of Burgers' equation, which describe sound beams in dispersive and inhomogeneous media.

Diffraction of sound by noise barriers

Researchers: Bengt Enflo, Graduate student: Ivan Pavlov

Sponsors: BFR, KFB

Noise from traffic, fans, motors etc. is often shielded by barriers. In normal design the top edge of a noise barrier is straight. The edge may act as a string of highly correlated point sources. The effectiveness of the barrier is reduced by the coherence of these secondary sources. Experiments at The University of Texas show that the effectiveness of the barrier can be increased if it is made irregular. The project aims at understanding of these phenomena by theoretical methods. It will continue with theoretical and experimental investigations of possibilities of increasing the effect of sound barriers.

Dynamical systems and multi-body modelling

Researchers: Martin Lesser, Hanno Essén, Arne Nordmark, Graduate Students: Mats Fredriksson, Anders Lennartsson

Sponsor: TFR, LUFT

The purpose of this study is to integrate modern methods of modelling multi-body systems with recent results in the theory of dynamical systems. Thus far most dynamical systems treated under the new heading of chaos theory has involved concentration on very low degree of freedom models derived in a somewhat ad-hoc fashion as representations of more complex mechanisms. Our aim is to combine our new techniques for dealing with complex mechanisms by computer algebra and Kanes equations with the methods of dynamical systems theory to achieve useful and readily interpretable representations, e.g. by means of center manifold ideas. One particular area of interest is problems of impact in subassemblies of complex mechanisms.

Publications: 13,47

Mechanics of The Vasa Steering System

Researchers: Martin Lesser Graduate Students: Anders Lennartsson, Jesper Adolfsson, Gitte Ekdahl. Cooperative Researchers: Dr. Thomas Wright, Science Museum, London

Sponsor: Internal Funds

The steering mechanism of the Vasa, known as a "whipstaff" was of the type used in ships for a thousand years. It is the only surviving example of this device which for the most part has gone undocumented. A number of issues concerning the way the mechanism has been reconstructed, how it was used and the possible problems of physical damage to the steersman in carrying out his task are at issue. The project, in cooperation with the Vasa Museum and the Science Museum in London is designed to answer these questions. As part of the work we are preparing a simulation of the mechanism which will be placed in the Vasa museum. The simulation is partly an actual copy and partly a servo steered mechanism run by a computer program. Users will get some of the sense of what was involved in steering the ship.

Design of complex mechanical systems

Researchers: Martin Lesser, Sören Andersson (Machine Elements), Lennart Karlsson (Computer Aided Design, Luleå), Tore Risch, (Computer Science Linköping), Volvo Corporation. Graduate student at KTH: Claes Tissel

Sponsor: NUTEK

Complex mechanical systems are treated by a combination of modern methods for simulation, computer aided design tools and object oriented data base technology. The aim of the project is to assemble all of these techniques into a usable design tool. Several particular problems are being used as test cases. These include blade mountings in jet engines and exhaust manifold in automobiles.

The Mechanics of Overhead Railroad Electrification Systems

Researchers: Martin Lesser, Anders Lennartsson, Gitte Ekdahl *Cooperation with:* Professor Lennart Karlsson, Division of Computer Aided Design, LUT

Sponsors: Swedish State Rail Authority, Banverket.

This is an experimental, theoretical and numerical study of the overhead electrification system used in high speed trains. Both the pantagraph mechanism, which sits on the roof of the train and the overhead cabel system are treated. The purpose of the project is to determine what are possible damage mechanisms to the device, what are the speed limits set by it and what criteria may be used in evaluating possible interactions of new type pantagraphs with the Swedish rail systems power lines.

Publications: 50

Theoretical acoustical investigations with applications in musical acoustics

Researcher: Christer Nyberg

Sponsor: LUFT

The purpose of this project is to investigate nonlinear generation of combination frequencies in cavities. The tone generation in musical instruments is often described in terms of a clearly defined nonlinear element which can excite the rest of the instrument, treated as a linear, passive, multimode cavity. However, linear theory, which requires small amplitudes, seems to be inadequate for describing the sound field in a cavity close to a resonance, as finite amplitudes are predicted even with dissipative effects included. If the sound field is excited by two frequencies close to resonance, nonlinear interaction is therefore expected to become important. Starting with a nonlinear generalization of d'Alembert's wave equation together with appropriate boundary conditions, the acoustic wave field in the cavity is calculated and can then, in the case of periodicity, be decomposed into its Fourier-components.

Publications: 37

Continuum Mechanics of Moderately Rarefied Gases

Researcher: Lars Söderholm; *Graduate student*: Naoki Yoshida.

Sponsor: LUFT, TFR

The mean free path of a molecule in a gas is usually quite small in comparison with relevant lengths, so that the Navier-Stokes equations apply. If, however, the gas is rarefied, as in very high altitude flight, or if the relevant lengths are very small, as for flow around very small bodies, the Navier-Stokes equations are no longer applicable. Flow around very small bodies is of increasing technnical importance.

13 moments equations have besides the usual continuum mechanical variables density, velocity and temperature also heat current and viscous pressure tensor as dependent variables. Modified 13 moments equation, which, in contrast with the Grad 13 moments equations, are correct to first order in the mean free path have been established and are studied.

The Burnett equations are of third order in density, velocity and temperature, whereas the Navier-Stokes equations are of second order. They are formally correct to second order in the mean free path, but plagued with several difficulties, like instability for short wavelengths and unknown boundary conditions. The relation between the Burnett equations and the equations of the Hilbert-Grad-Sone expansion is studied and methods for stabilization of the Burnett equations are being developed. Heat transfer to particles small compared with the mean free path is studied.

Publications: 42

Relativity, Non-linear Waves and Integrability

Researcher: Lars Söderholm; *Graduate student*: Naoki Yoshida.

Sponsor: LUFT.

Relativistic fluid dynamics has to be applied when macroscopic or thermal speeds are comparable to the speed of light. It is important that the equations are causal, so that no disturbances propagate faster than light. The relativistic generalization of the Navier- Stokes equations are not causal, as in the rest frame of the fluid shear diffuses with infinite speed. The recently obtained 13 moments equations correct to first order in the Knudsen number are extended to relativistic conditions. All modes propagate as waves.

Most integrable equations are weakly non-linear approximations such as the Korteweg-de Vries equation and the non-linear Schrödinger equation (valid for long and short water waves, respectively). The fully non-linear field equations of general relativity are, however, exactly integrable when sufficient symmetry give just two independent variables. Integrable equations can be considered intrinsically linear as they via (non-local) transformations can be reduced to linear equations. This calls for an intrinsic, geometric description. In general relativity such methods have been employed for a long time. The field equations of general relativity are studied for the axially symmetric case.

Time-Dependent Normal Form Hamiltonian

Researchers: K.-E. Thylwe, in collaboration with Dr H. Dankowicz and Prof H.-J. Korsch (Kaiserslautern, Germany).

Sponsor: 'Rörlig resurs, KTH'.

The research focuses on the development and application of a new normal form for physically relevant time-dependent Hamiltonian systems. This theory is of significance in various physical contexts:
– In semiclassical quantization of mixed chaotic model systems with soft potentials;
– In certain simplified models of electromagnetic wave propagation where the nonlinear Schrödinger equation plays a central role;
– In other situations such as pattern formation and instabilities in infinite dimensional systems; the relevant class of equations appear in searching for stationary solutions of non-homogeneous, dissipative partial differential equations.

The TD normal form is also an elegant framework for obtaining adiabatic approximations, i.e. assuming slow variations in the coefficients, in the above applications.

Publications: 18

6.2 Fluid mechanics

Experiments on stability, transition, separation and turbulence in boundary layer flows

Researchers: Henrik Alfredsson, Andrey Bakchinov, Per Elofsson, Carl Häggmark, Michael Katasonov, Mitsuyoshi Kawakami, Masaharu Matsubara, Alessandro Talamelli, Nils Tillmark, Johan Westin

Sponsors: NUTEK, TFR, KVA, Göran Gustafsson stiftelse, Axel och Margaret Ax:son Johnsons stiftelse.

The first aim of this project is to understand the transition process in laminar boundary layers which are subjected to free stream turbulence. The second object is to be able to control and hopefully delay the transition process. Several studies in our laboratory have dealt with the receptivity of the laminar boundary layer to free stream turbulence, through detailed velocity measurements in the MTL wind tunnel, where free stream turbulence is generated by different grids. Both flow visualisation and hot-wire measurements (one and two-point) have shown that the interaction with the boundary layer gives rise to elongated structures of high and low velocity. The streaks are susceptible to secondary instabilities and will subsequently break down into turbulence.

Formation of elongated structures may also occur through the interaction between two finite-amplitude oblique waves. This, so called, oblique transition scenario has been investigated in a laminar boundary layer in the MTL-wind tunnel where the waves have been generated through a spanwise slot connected to up to six different loudspeakers. Both flow visualisations and extensive hot-wire measurements have been made. An experiment has been designed to study the secondary instability of streaks. These experiments were made in a channel where the streaks are formed through regularly spaced suction holes. If the streaks are strong enough, natural secondary instability develops and the flow breaks down to turbulence. Secondary instability of the streaks is also studied by introducing controlled disturbances.

Figure 2: A flow visualization photograph showing oblique transition in a flat plate boundary layer flow. The free stream velocity is 8.4 m/s and the flow is from left to right. The picture is approximately 220 mm wide and 420 mm long. The left hand side is 240 mm from the plate leading edge (flow visualization by Elofsson).

The separation and transition of a laminar boundary layer on a flat plate subjected to an adverse pressure gradient is also studied. The pressure gradient is imposed by an adjustable bump mounted at the upper wall, forcing separation at the plate. Hot-wire measurements and flow visualizations showed that the front part of the separation bubble induced on the plate was 2D and steady whereas in the reattachment region an unsteady 3D vortical shedding motion appeared. Flow visualizations further revealed a spanwise periodicity of these vortices. So far experiments on the response of the bubble to the natural wind tunnel disturbances (low level disturbances), controlled disturbances in form of TS-waves as well as grid generated free stream turbulence (FST, level 1.5 %) have been studied. Under low disturbance conditions frequency spectra from the shear layer show a quite distinct peak from the wave packets indicating that there is a strong wave frequency selection in the shear layer. These waves can be studied in more detail by introducing two-dimensional deterministic waves upstream of the separated region. In the negative pressure gradient boundary layer upstream of the bubble the waves are damped while in the separation region they are strongly amplified (several orders of magnitude). The influence of excitation amplitude and frequency of the waves on the mean flow has been investigated. FST was found to have a significant effect on the structure of the separation bubble and reduced the size of the separated region. Initially the disturbance growth was found to be exponential for the 2D waves and linear in the FST-case, but seemed to saturate at the same level in both cases. A related study of numerical simulations of separated flows is carried out by Prof. Henningson.

In connection with the separation experiments a new three wire probe has been developed. The three wires are parallel and in the same plane. The centre wire is run as a conventional hot-wire whereas the two outer wires are run as temperature sensors thereby feeling the temperature wake of the centre wire. These two wires are coupled as two legs of a Wheatsone bridge, thereby giving a signal which directly gives the flow direction. It has been shown that this wire can distinguish reversed flow and thereby increase the accuarcy for measurements in and around the separation bubble.

Another experiment to better understand the interference between an X-wire and the wall has also been undertaken. An X-wire configuration was set up from two slanted wires which could be moved relative to each other. The measurements were made in a fully developed turbulent channel flow. It was shown that the presence of the wall displaces the effective cooling position of the wires and thereby gives erroneous results close to the wall. These measurements are still under evaluation, but it seems possible that correction procedures will be possible for such measurements.

In cases where body forces affect boundary layer flows different other types of instability may be dominating. For instance a boundary layer flow along a wall in a rotating system will be affected by a Coriolis force which can give rise to instabilities in the form of longitudinal vortices. These instabilities may arise at much lower Reynolds numbers than the traditional TS-wave instability. The secondary instability has been studied through controlled experiments in an air channel with system rotation.

For plane Couette flow with system rotation, the Coriolis force will either be stabilizing or destabilizing across the full channel width. Linear stability theory shows that the critical Reynolds number is as low as 20.65. Our experiments have verified the linear theory and also shown that the flow exhibit a number of interesting secondary instabilities which occur on top of the primary roll cell structure. The experiments show furthermore that rotating plane Couette flow exhibits a rich variety of flow phenomena, some of which has not been observed in other flow situations, such as relaminarization for stabilizing rotation. PIV measurements are underway to study plane Couette flow both in the rotating and non-rotating cases.

Publications: 1,19,51,59,71

Fluid dynamics of plane liquid jets

Researchers: Henrik Alfredsson, Daniel Söderberg

Sponsors: FaxénLaboratoriet

In the paper making industry plane jets of a low concentration fiber suspension distributes the fibers to the paper machine. For a typical paper machine the jet width can be 10 m with a thickness of about 1 cm, and velocities of the order 10-30 m/s. The flow is ideally two-dimensional, however, paper is usually not perfectly homogeneous across its width, showing that the jet flow is not perfect. This can be due to inhomogeneities in the jet contraction, centrifugal instability in the form of Dean vortices or inhomogeneous break-up of the jet. For plane jets the surface is affected both by a surface tension force which always tends to restore the interface back to its original equilibrium position, whereas the aerodynamic forces developing at the interface between liquid and gas enhance the instability. This may cause the instability to grow until the liquid sheet disintegrates and splits up into droplets. The research program aims at increasing our knowledge about the development of two-dimensional liquid jets in air, both for Newtonian liquids (i.e. pure water) and fiber suspensions typical for paper making.

Publications: 41,65

Modelling of solidification in materials processing

Researchers: Gustav Amberg, Robert Tönhardt

Sponsors: TFR, KTH (rörlig resurs).

During solidification, for example in casting or welding, mushy zones consisting of dendritic crystals often form. The properties of a finished casting are determined by the size and morphology of the crystals, and is often strongly affected by convective heat and mass transfer during solidification. This project is concerned with mathematical models for solidification in processes such as welding and near net shape casting. One part of this is to predict microstructure, i.e. the crystal structure and the size, geometry and orientation of crystals. The models developed within the project are to be incorporated in available codes for simulating the macroscopic convective heat and mass transfer during solidification. Development of mathematical models will require simulations of individual dendrites. Models and predictions will be continuously tested against experiments (in collaboration with Hasse Fredriksson, KTH).

Another issue which is studied is the rather complex dynamics of convective flow through the mushy layer, giving rise to well known defects such as macrosegregation and freckles. Such specific phenomena has been studied within this project and will be investigated further, using the code and models that are developed. During the work described above, symbolic code generation tools (www.mech.kth.se/ gustava/femLego) have been used to a large extent.

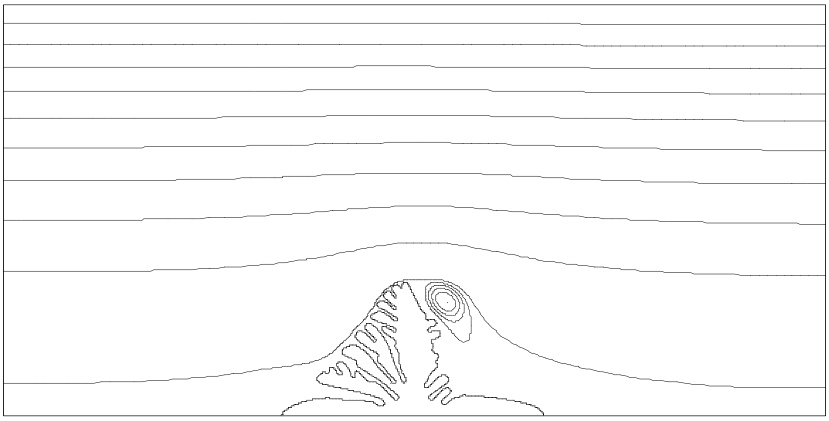


Figure 3: We study how the dendritic evolution of an initially small nucleus is affected by a mean external flow. The nucleus is considered to be attached to a solid wall, and it grows away from the wall into the melt. The melt is assumed to be flowing due to an applied shear stress far away from the wall. The fluid flow alters the local heat transfer at the solidification front, and thus the shape of the dendrite. Due to the flow the nucleus evolves to an asymmetric dendrite that tilts. Another effect of the flow is that the sidebranch-growth gets promoted and inhibited on the upstream and downstream side, respectively. We use an adaptive grid and finite element applied to the phase-field method in 2D. The adaptivity results in a high local resolution at the solidification front and a much coarser mesh away from the front. The parameters are Δ_c=0.5, Pr=0.03, Pe=5.0 and t=0.9, the domain size is 20×10. Innermost contour is the liquid/solid interface, the outermost is the domain boundary, and the other contours are streamlines. The stream-function has the value zero at the solid wall and the ten streamlines stretching from inflow- to outflow-boundary have values between 0.004 and 48.4, and are plotted with constant increment in value. The four closed streamlines behind the tip have values between -1.57 and -0.004, and are plotted with constant increment in value. (Δ_c = dimensionless undercooling=inverse of the Stefan-number)

Publications: 2,68

Thermocapillary convection in materials processing.

Researchers: Gustav Amberg, Henrik Alfredsson, Christian Winkler, Renaud Lavalley

Sponsors: TFR, KTH (rörlig resurs), Nippon Steel.

If surface tension depends on temperature, a fluid motion will be induced along a free surface with a temperature gradient. This is an important phenomenon in many materials processes, characterized by large temperature gradients, small volumes of liquid metal, and the presence of free surfaces. This convection is often crucial for the properties of the finished product. Examples of such processes are all the various techniques for crystal growth, and welding, where the flow in the weld pool determines the penetration of the liquid pool (i.e. 'weldability'). Often it is technically important to avoid oscillatory flow, and thus it is important to understand the stability characteristics of thermocapillary convection in general.

An experimental study of the transition from stationary to oscillatory motion in buoyant thermocapillary convection has been made. The instability was observed by flow visualizations and PIV measurements, and quantitative agreement was found with numerical calculations. The emphasis is on identifying instability mechanisms and to design efficient active control strategies to suppress oscillations.

Welding of the light metals Aluminum and Titanium today presents a number of practical difficulties. The flow in the melt during welding of Al and Ti alloys will be studied by numerical simulation, using tools and models developed in accompanying projects. This will be closely coupled to an experimental study of Al and Ti welding carried out by Torbjörn Carlberg, Sundsvall. The melt flow in stainless steel welding has also been simulated and compared to experiments performed at Nippon Steel, Futtsu, Japan.

Another process where thermocapillary convection is crucial is float zone crystal growth. The stability of the flow in such processes are simulated numerically and comparisons are made with actual float zone experiments in space and on earth (Torbjörn Carlberg, Sundsvall). During the work described above, symbolic code generation tools (www.mech.kth.se/ gustava/femLego) have been used to a large extent.

Cooperation with Torbjörn Carlberg, Sundsvall, Mårten Levenstam, CTH and Nippon Steel.

Publications: 45,60

Transport in electrochemical systems

Researchers: Fritz Bark, Lars-Göran Sundström, Michael Vynnycky

Sponsor: TFR

The purpose of this project is to provide the electrochemical industry with solutions to some fundamental problems whose understanding is of importance in the design of cells with a liquid electrolyte. In such cells, transport of ionic species is due to three different mechanisms – convection, migration (due to the electric field), and diffusion. The two latter are coupled via a condition of electroneutrality, whose validity has been studied in some detail. Reaction kinetics enters as boundary conditions on the electrode surfaces. The work is at present mainly theoretical, with experiences from previous experiments as a valuable basis. Both steady and time-dependent situations with and without natural convection are treated. Morphological instabilities, which cause the (unwanted) formation of dendrites, have been investigated, as well as solutal and hydrodynamic instabilities. Because of the analogy between heat and mass transfer, many of the results are directly applicable to heat transfer cases. As regards to multi-phase transport, some theoretical work on diffusion in porous electrodes and separators has been completed during the year.

Publications: 64

Computing the two-phase flow in gas-evolving, electrochemical cells

Researchers: Anders Dahlkild, Ruben Wedin

Sponsors: FaxénLaboratoriet

This work aims at develop computational tools for flow in electrochemical reactors with gas-evolving electrodes. Focus is on the effect of the gas bubbles on the process, which are used to force a circulating convective flow of the electrolyte in the reactor. Two-phase flow models are applied compute bubble concentrations and flow velocities in different parts of the reactor. First, a global model is formulated for the whole reactor, where available two-phase flow models of the commercial software CFX is used. An important question to answer is e.g. to predict the flow distribution of electrolyte through the various channels of the electrode packet depending on reactor design. Secondly, a more detailed model of the flow between an electrode pair is developed. A source of bubbles appear on the surface of a gas-evolving electrode. Since the hydrogen bubbles studied are very small, the transport of bubbles away from the electrode in laminar flow conditions is obtained from available models of hydrodynamic diffusion of small Reynolds number-particles.

Publications: 30

Computing the flow of a wire nip

Researchers: Gerald Audenis, Anders Dahlkild

Sponsors: FaxénLaboratoriet

This work aims at an understanding of the fluid dynamics of a plane jet impinging on a wire nip of a paper machine. Focus is on the dewatering process through the wire and the development of the pressure pulse on the dewatering roll. A numerical method is developed to calculate the free surface of the jet for a constant permeable wire or a wire with prescribed but variable permeability.

Computing the flow of a stratified headbox

Researchers: Anders Dahlkild, Mehran Parsheh

Sponsors: FaxénLaboratoriet

Using the commercial fluid dynamics software CFX, we have modeled the mixing of the different layers of a three-layer stratified headbox jet. We have studied the transport of a passive scalar component dyed into the middle fluid layer to the other layers. It has been found that vane length has considerable and vane tip shape has little effect on mixing. Vanes shorter than the headbox cause less mixing and vanes longer than the headbox cause more mixing. Parallel slice lips worsens the mixing. Furthermore, the nozzle angle was changed and the optimum angle was found to be between 8-11 degrees.

Publications: 40

Hypersonic afterbody flow fields

Researchers: Tor-Arne Grönland, Anders Dahlkild

Sponsors: ESA

This work is part of a research project performed external to KTH by the team FFA and DASA. The aim of the study is to make a thorough and basic investigation of the importance of different physical and geometrical effects which influence the efficiency and versatility of a hypersonic afterbody design. The complete propulsion system is an integrated part of the airframe of a hypersonic airbreathing vehicle. The vehicle body will act as expansion surface, yielding an unsymmetric expansion of the engine exhaust gases to the surrounding pressure. In the design of such an afterbody there are a number of critical issues of which one needs a thorough knowledge.

Publications: 55

Control of low-dimensional models of the turbulent boundary layer

Researchers: Harry Dankowicz, Brian Coller (California Institute of Technology)

Sponsor: The Göran Gustafsson Foundation

We study low-dimensional models of the turbulent flow in boundary layers. in particular, we apply the evolutionary algorithm known as Genetic Programming to finding suitable control strategies for the suppression of burst-type behavior in the models. These bursts are thought to be essential in the production of turbulence in the main flow

Large Eddy Simulation of swirling jets

Researchers: Magnus Olsson, Laszlo Fuchs

Sponsor: TFR

"Dynamic" Large-Eddy-Simulations (D-LES) have the advantage that the model is parameter free. It also offers the possibility of treating transitional flows as the model "shuts" itself "down" in laminar regions. One of the main issues that is addressed here is the way of determining the validity of the basic assumption that the model has reached an "asymptotic" behaviour. Furthermore, one has to be able to distinguish between the truncation errors and the generalized moments (which may contain numerical errors due to the way the double spatial filtering is carried out!). Furthermore, other "asymptotic" SGS models have also been developed and implemented. The technique has been tested/applied to spatially developing free- and impinging jets and to the mixing (of passive scalar) in such jets.

Publications: 16,38,62

Numerical Simulation of Flows of Fluids Containing Small Particles

Researchers: Per J. Olsson, Laszlo Fuchs

Sponsor: NUTEK

In multiphase flow, the models used to describe the presence of particles in a fluid usually ignore the force interaction among particles and a fluid flow governed by the Navier-Stokes' equations. In order to gain some insight into the physical phenomena in a "micro" flow environment, we study the interaction among fixed solid spheres and the surrounding fluid. To study the rheology of such systems, a mixture viscosity is computed from the numerical simulations where a shear flow is applied to a field of spherical particles. Due to the presence of attracting and repelling forces that depend on the geometrical configurations, one expects intensive and complex motion of the particles when they are allowed to move freely.

Publications: 39

Boundary layer transition – Theory and DNS

Researchers: Dan Henningson, Stellan Berlin, Casper Hildings

Sponsors: TFR, NFFP, FFA

This project involves research to determine the maximum growth possible of disturbances evolving according to linear theory, as well as to investigate the importance of this growth when non-linearity comes into play. Several shear flow types have been considered. The results show that non-modal growth, i.e. growth not associated with individual eigenmodes but inherently dependent on their superposition, can cause large transient amplification. This growth is mainly associated with streaky structures in the streamwise direction. Non-linear calculations have shown that when the optimal disturbances from linear theory are used as initial conditions, the threshold amplitudes required for transition to turbulence is lower than for general disturbances.

Another part of the project involves direct numerical simulations (DNS) of transition to turbulence where these transient growth mechanisms play a major role. This bypass of the traditional Tollmien-Schlichting instability waves is involved in many shear flow transition scenarios. Previously transition associated with localized disturbances have been investigated, and at present the transition in boundary layers starting with a pair of oblique waves is investigated. These waves generate elongated structures in the streamwise velocity which rapidly grow due to the non-modal mechanism.

Finally transition in flows with separation is considered. Here DNS of a laminar separation bubble is investigated and disturbances added in order to study laminar separation and turbulent reattachment.

Publications: 3,15,17,57

Active Control of Boundary-Layer Transition

Researchers: Markus Högberg, Martin Berggren, Dan Henningson

Sponsors: TFR, NGSSC, FFA

Study and design of active control strategies for transition in boundary layer flows is done within this project. The control strategies will are designed using the optimal-control approach to control of the Navier-Stokes equations and the adjoint-equation technique for associated gradient computations. The strategies will be designed to control or delay bypass transition. This represents a significant new step compared to previous work almost exclusively devoted to anti-phase modal suppression of two-dimensional TS-waves or wave packets. In particular the aim is to control the growth of streaky structures associated with most bypass transition scenarios. The application is flows with free-stream turbulence, where an optimally designed feed-forward control will be implemented experimentally to delay transition.

Modern stability prediction methods

Researchers: Paul Andersson, Ardeshir Hanifi, Dan Henningson, Martin Berggren

Sponsors: NUTEK, FFA, KTH

The project concerns a new transition prediction tool which is being developed in cooperation with DLR in Gottingen. The code uses the parabolized stability equations (PSE) and is so far based on the linearized equations. The method uses a wave ansatz with a slowly varying amplitude function and wave number, similar to the WKB method. In addition an auxiliary condition is introduced which ensures uniqueness of the solution so that the traditional WKB expansion can be avoided. This method has proven to be efficient and to produce accurate stability results for complicated flows. It has been carefully checked against existing solutions and will be extended to handle non-linear interactions between wave components.

Applications motivating the development of this method is the hypersonic transition research carried out within the ESA FESTIP program and laminar wing design carried out in the CEC EUROTRANS program.

A new direction in this research is to use optimization methods to predict the transition location in flows with high free-stream turbulence levels. This is done using adjoint methods, similar to those used in the active control project, and parabolic approximations for the stability problem. A new transition prediction method has been proposed.

Publications: 23,24

Calibration and development of turbulence models

Researchers: Martin Skote, Dan Henningson

Sponsors: NUTEK, PSCI

Correct modeling of turbulence is one of the most crucial areas for design computation of flow around wings and aircraft configurations.

Current models are not accurate enough for many common flow cases, especially when they contain zones of separated flow. The progress towards more reliable turbulence models is considerably slowed down by the problems of calibration of these more complex models and by the numerical problems they induce, in particular close to solid surfaces.

While most of the current model calibration relies on experiments, the advent of faster computers now allows simulation of turbulent flow at increasing Reynolds numbers. From simulated data each term in the exact model equation can be computed individually and the model calibrated term by term.

High quality simulation data applicable to calibration is at present scarce. This is especially true for the aeronautically important cases of three-dimensional and separated boundary layers.

In the project we simulate turbulent boundary layers for a number of flow cases including adverse pressure gradient and separated flow with parameters in the range of interest for aeronautical applications. From the simulated data, turbulence models in current use for aerodynamic design are validated and/or calibrated. The problems associated with more advanced turbulence models in the near wall region are also considered.

Publications: 34

Measurement, modelling and simulation of turbulence

Researchers: A.V. Johansson, K. Alvelius, T. Hambraeus, T. Sjögren, S. Wallin, P. Wikström

Sponsors: TFR, NUTEK, The Göran Gustafsson Foundation, KTH

The aim of the project is to develop and critically evaluate models for statistical description of turbulent flows. The main methods used within the present project for gaining further knowledge of the physics of turbulence are experimental studies and direct numerical simulations of turbulent flows. These methods are complemented by so called rapid distortion analysis and to some extent also by spectral theories. The models so far investigated belong to the realm of one-point closures for the turbulent stress tensor and turbulent heat flux vector to be used for computational fluid dynamics. The main emphasis is laid on closures based on the transport equations for the turbulent stresses. Particularly, our efforts have been focused on the modeling problems of flows exhibiting strongly anisotropic turbulence. A number of terms responsible for intercomponent energy redistribution have been scrutinized and models for the individual terms have been proposed. The models are cast in continuum mechanics type of tensor formulations and satisfy basic principles such as realizability of the solutions produced by the closure.

New formulations of explicit algebraic Reynolds stress models have been derived and tested with considerable success in a number of test cases including complex cases such as a Mach 5 turbulent boundary layer with shock induced separation. The new EARSM model has also been applied to flows around stall-regulated wind turbine blades. Also formulations of explicit algebraic Reynolds flux models have been derived and tested against experiments and direct numerical simulation of passive scalar transport in a turbulent channel flow. A large effort has also been devoted to formulations of Large Eddy Simulations in homogeneous turbulence and in channel flow geometry. For the latter case there are also ongoing direct numerical simulations for various rates of system rotation.

A new wind-tunnel is presently under construction which together with the MTL tunnel will be the primary experimental tools in this project.

A main underlying theme has been the improvement of understanding of the many aspects involved in the development of single point closures of turbulence. Among recent major achievements of the group in the modelling area we may mention:

- new models for dissipation rate anisotropy, and slow and rapid pressure strain rate
- the first direct experimental determination of slow and rapid pressure strain-rate
- new versatile, interactive tools for testing and calibration of turbulence models
- new explicit algebraic models for the Reynolds stress tensor and the passive scalar flux vector

Publications: 21,22,43,44,46,63,69,70

Numerical simulation of fully developed wall-bounded turbulent flows

Researchers: Arne Johansson, Jukka Komminaho

Sponsors: KTH

A new code for the direct numerical simulation of turbulent pipe flow is being developed. It is based on spectral methods in all directions. This technique has so far not been successfully applied to this problem although attempts in this direction have been pursued by some research groups. The complexity of the albebra involved is quite severe and so far parts of the code have been shown to work correctly.

Also fully developed turbulence in plane Couette flow has been studied by means of direct numerical simulation. Experience has shown that this is a particularly difficult case to study because of a tendency to develop extremely long vortical structures aligned in the streamwise direction. For a numerical simulation study an extremely long (and also rather wide) box is needed, almost 90 half-heights long in the present case. Accurate statistics have been acquired and the long structures have been studied in detail. It was also shown that a weak (spanwise) rotation has a drastic effect on the long structures. Comparisons with experimental results of Tillmark & Alfredsson show excellent agreement. Also the relaminarization of plane Couette flow turbulence was studied by a stepwise lowering of the Reynolds number (see figure). The transition Reynolds number could hereby be determined to about 360 thereby substantiating the previous numerical/experimental findings of Lundbladh & Johansson and Tillmark & Alfredsson.

Publications: 35,36

Turbulent boundary layers at high Reynolds numbers and new wind-tunnel design techniques

Researchers: Arne Johansson, Jens Österlund, Björn Lindgren

Sponsors: NUTEK, The Göran Gustafsson Foundation

For turbulent boundary layers typical Reynolds numbers are in most applications very high, whereas most laboratory experiments have been carried out at low to moderate Re. In the present project boundary layer measurements are carried out in the MTL wind tunnel at KTH, on a 7 m long boundary layer plate and with free-stream velocities up to 50 m/s. This gives Reynolds numbers based on momentum loss thickness of up to 20,000 or roughly 20 million based on x, which is realistic for practical applications. Hot-wire anemometry is used with X-probes with box sides down to 0.10 mm. However, severe restrictions in the method have been identified that are coupled to interaction of the thermal wakes from the wires (occurring at low Peclet numbers). Also new types of probe geometries are tested. A traversing equipment especially suited for measurements in the near-wall region has been constructed and new measurements using single and double probe arrangements are under way.

Measurements of fluctuating wall shear stress with a number of different types of probes have been carried out. Among the techniques are the 'hot-wire on the wall' technique and a new MEMS type of sensor developed at UCLA-Caltech. This silicon based sensor was recently tested in the MTL tunnel and was found to have a performance superior to that of traditional hot-films.

A new wind-tunnel is under construction and is planned to be operational during 1998. A special feature of this tunnel is that expanding corners are used to eliminate a substantial part of the need for diffusers. In fact, all the area expansion in the plane of the circuit is given by the corners (in total a factor of three). The contraction ratio of nine is achieved by the use of plane diffusers with a total expansion of a factor of three in the direction normal to the plane of the wind-tunnel circuit. The tunnel will be used for a variety of applications with a test section construction that enables easy variation of the design.

Publications: 14

Development of 3D LDV measurement techniques with applications to wall bounded shear flows

Researchers: Rolf Karlsson, Jan Eriksson

Sponsors: NUTEK, Vattenfall Utveckling AB

The aim of the project is to develop a practically useful methodology for making simultaneous 3D LDV measurements with high spatial and temporal resolution, and to apply this technique to obtain detailed 3D turbulence data in the plane turbulent wall jet. In a longer perspective, such data will be used to improve near-wall Reynolds stress turbulence modelling. The first phase of the project has now been successfully completed, and measurements in an enclosed circular jet with a measuring volume as small as 0.035 mm have been made.

The second phase of the project is to supplement an earlier (2D) experimental investigation of the turbulent wall jet with simultaneous 3D measurements of the total velocity vector. In particular, attention will be focussed on the equation for the turbulent kinetic energy and on the limiting behaviour of the Reynolds stresses near the wall. Such measurements are presently going on.

The 3-component LDV measurements of phase 2 have now been concluded, and a thorough analysis of the results is performed. A paper describing the 2-component measurements has been written and accepted for publication in Exp. Fluids. This experiment has also been used as a test case at the ERCOFTAC/IAHR Workshop on Refined Flow Modelling, Paris April 1996 and will also be used in the next workshop in Delft June 1997.

Together with Prof. W.K. George, USA, and a group at Chalmers Univ. of Technology, a similarity theory of the plane wall jet is under development.

Two-dimensional trubulence and diffusion of passive scalars therein

Researchers: Erik Lindborg & Erik Aurell, Dept. of Math. SU

Sponsors: TFR & KTH

The project aims at a deeper understanding of turbulent flows that qualify as two-dimensional as a first approximation and diffusion of passive scalars in such flows. The dynamics of the upper atmosphere is the application which will be particularly investigated. Fundamental insight into the dynamics of quasi-two-dimensional flows is important when several problems of great practical importance are dealt with, such as the dispersion of pollutants, the dynamics of the ozone-layer and weather prediction. The project will tie together the activities of Erik Aurell (Dept. of Math., SU) with the turbulence group at the Dept. of Mech., KTH, in particular Erik Lindborg, and will greatly benefit from the combination of contributions from these two Departments. The methods used are: fundamental analysis of the governing equations, development of simple mathematical models, direct numerical simulations (DNS), analysis based on the MOZAIC data set (wind and temperature measurements from over 6000 flights in the upper atmosphere) and finally a systematic comparison between the results from modeling, DNS and data analysis.

6.3 Education didactics

FLIP-Flexible Learning in Physics and Mechanics

Researcher: Christer Johannesson, Göran Karlsson, Ian Cohen

Sponsors: (The Swedish) Council for the Renewal of Undergraduate Education and KTH (central support and Mechanics and Physics departments)

Industrial and international contacts: University of Plymouth, University of Surrey, University of Brighton

FLIP is a three year project in conjunction with Department of Physics at KTH, Department of Physics at Stockholm University, Department of Mechanics at the University of Linköping, and Department of Mathematics at University of Plymouth, UK. The main intention is to (i) incorporate interactive computer programs in the existing courses; (ii) develop a Learning Center in the teaching program at KTH; (iii) introduce the international computer network as a tool for special assignments and in project work; (iv) develop and introduce new forms for student examination. At KTH and Stockholm University 6 FLIP seminars and workshops have been arranged during the year.

The project financing expired June 30, 1997 but due to savings of funds it has continued even after that date.

At KTH a special room has been furnished and equipped with 5 PC having Internet connectivity. This is the embryo for the Learning Center. SToMP (Software Teching of Modular Physics), CUPS (Consortium of Upper Physics Software), IDA (from KTH Dept. of Electromagnetic Theory), Optics software from State University of Moldova, and Interactive Physics have been installed on these computers.

SToMP and CUPS have also been entered to the KTHCD 96/97 AND KTHCD 97/98 (Projcet Teknologers Datorkraft). KTH has a total site license with LIAB Läromedia to use Interactive Physics (for mechanics intsruction) from Knowledge Revolution. KTH also has a site license with University of Surrey, Guildford, UK to use SToMP (Softwre Teaching of Modular Physics).

Publications: 25,26,27,28,29

CECEN - Continuing Education Centres Network in the Oltenia Region

Researcher: Göran Karlsson

Sponsors: EU: TEMPUS JEP 12083-97

Industrial and international contacts: Swedish TelePedagogic Knowledge Center AB, Nyköping (SE), GruppvaruExperterna i Sverige AB/FCSweden, Uppsala (SE), University of Craiova (RO), Eindhoven University of Technology (NL), Universität der Bundeswehr, München (DE), Ecole des Mines, Paris (FR), Education Institute of Pireus (GR), Universitatea "Constantin Brancusi" Targu-Jiu (RO), Universitatea din Petrosani (RO), COREP (IT), CIFATT-Center for Technological Transfer, Craiova (RO), INSEMEX Petrosani (RO), Chamber of Commerce and Industy of Gorj Department, Targu-Jiu (RO), CDIMM, Craiova (RO)

The objective of the project CECEN is the setting up of a continuing education and retraining centres network 'CECEN' in the Oltenia region in southeast Romania with a multi-disciplinary approach in the areas of high technology (Telecommunications, Computer Science, Software Engineering, Robotics, energy production, mining, public administration, quality control, tourism.)

The main outcome of the proposed project envisages setting up of Oltenia University Enterprise Liaisons Centres Network (OLC) aimed for continuing education and retraining for university graduates in the Oltenia region. The regional approach of such an complex endeavour is basically the gradual solution of implementing the restructuring reform of higher education having as an endpoint the future interconnection. These centres are located in all Oltenian universities, Craiova, Petrosani and Targu-Jiu and the major activity planned in are short- and medium-term retraining/ updating courses including complementary education in a multi-disciplinary approach. Among other forms of courses, there are planned short intensive courses held by professors from EU partner universities and organisations and short intensive courses for data communications node administrators. These centres (OLC) are to be interconnected via a regional academic computer network as a part of ROEDUNET (Romanian Academic Network).With the contribution of EU university partners a credit recognition transfer scheme for the complementary education, compatible to ECTS, is proposed.

Publications: 73

7 Research activities

7.1 Doctoral theses defended 1997

Magnus Olsson

Thesis title: Large-eddy simulation of turbulent jets.

Date: March 24, 1997
Faculty opponent: Prof. Joel Ferziger, Stanford Univ. USA
Evaluation Committee: Dr Farid Alavyoon, Vattenfall Utveckling AB, Prof. Lars-Erik Eriksson, Volvo Aero Corp., Prof Håkan Gustavsson, LuTH.
Main Advisor: Prof. Laszlo Fuchs

Magnus has started on a position at Adtranz.

Torbjörn Sjögren

Thesis title: Development and calibration of turbulence models through experiment and computation

Date: April 25, 1997
Faculty opponent: Dr N. Mansour, NASA Ames Research Center
Evaluation Committee: Dr Mats Ramnefors, Volvo Data, Prof Håkan Gustavsson, LuTH, Prof Lennart Löfdahl, Chalmers.
Main Advisor: Prof. Arne Johansson

Torbjörn has started on a position at Volvo Data.

Johan Westin

Thesis title: Laminar-turbulent boundary layer transition influenced by free stream turbulence

Date: May 30, 1997
Faculty opponent: Prof. Kenneth Breuer, MIT
Evaluation Committee: Dr Rolf Karlsson, Vattenfall Utveckling AB, Dr F. N. Shaikh, Engineering Department, Queen Mary and Westfield College, London Prof. John Kim, Mechanical and Aerospace Engineering Department, University of California, Los Angeles
Main advisor: Prof. Henrik Alfredsson.

Johan has started on a position at Vattenfall Utveckling AB.

Sima Zahrai

*Thesis title:*On the fluid mechanics of twin-wire formers

Date: November 14, 1997
Faculty opponent: Prof. Douglas W Bousfield, Univ. of Maine

Evaluation Committee: Dr Bengt Nordström, Sundsvall, Dr D. Wahren, Falun, Prof. Håkan Gustavsson, LuTH.
Main advisor: Prof. Fritz Bark.

Sima has started on a position at ASEA Atom AB.

Lars-Göran Sundström

Thesis title: Studies on mass transfer in elechtrochemical systems

Date: November 20, 1997
Faculty opponent: Prof. Antoine Alemany, LEGI, INPG, France
Evaluation Committee: Dr Farid Alavyoon, Vattenfall Utveckling AB, Doc. Göran Lindbergh, Applied Electrochemistry, KTH, Prof. Noam Lior, Univ. of Pennsylvania.
Main advisor: Prof. Fritz Bark.

Lars-Göran has taken a post-doc position IMG, Grenoble.

7.2 Licentiate theses presented 1997

Daniel Söderberg

Thesis title: Experimental and theoretical studies of plane liquid jets.
Advisor: Prof. Henrik Alfredsson

Daniel presented the thesis at a licentiate seminar in January 1997 and is continuing his graduate studies towards a doctoral degree.

Jesper Adolfsson

Thesis title: A study of stability in autobalancing systems using multiple correction masses.
Advisor: Prof. Martin Lesser

Jesper presented the thesis at a licentiate seminar in February 1997 and is continuing his graduate studies towards a doctoral degree.

Tor-Arne Grönland

Thesis title: A study of hypersonic afterbody flow fields.
Advisor: Dr Anders Dahlkild

Tor-Arne presented the thesis at a licentiate seminar in March 1997 and is continuing his position at FFA.

Krister Alvelius

Thesis title: Large-eddy simulation of homogeneous turbulence.
Advisor: Prof. Arne Johansson

Krister presented the thesis at a licentiate seminar in June 1997 and is continuing his graduate studies towards a doctoral degree.

Koji Fukagata

Thesis title: Large Eddy Simulation of Particulate Turbulent Channel Flows.
Main advisor: Prof. Fritz Bark

Koji presented the thesis at a licentiate seminar in June 1997 and is continuing his graduate studies towards a doctoral degree at University of Tokyo.

7.3 Conferences

The Enskog Heritage – A minisymposium September 23, 1997

The physics and mechanics of rarefied gases is at present attracting growing interest. One reason for this is the increasing miniaturization of computer components, machines and measuring probes. A central figure in the kinetic theory of gases is David Enskog (1884-1947). He was professor of mechanics and mathematics at KTH in the period 1930-1947. David Enskog - and independently Sydney Chapman - derived the Navier-Stokes equations from the kinetic theory of slightly rarefied gases. This made possible the calculation of viscosity and heat conductivity from the knowledge of intermolecular forces. At present higher approximations (for more rarefied gases) in the Chapman-Enskog expansion attract considerable interest and so does another achievement of David Enskog, the so-called Enskog equation, which pertains to denser gases.

On the occasion of the 50th anniversary of the death of David Enskog, a mini-symposium, *The Enskog Heritage*, was arranged, which showed the relevance of Enskog's ideas and contributions at present. The mini-symposium was organized by Lars Söderholm and Nicholas Apazidis and supported by the Nobel Committee of Physics. About 85 persons attended *The Enskog Heritage*. The program was as follows

- Janne Carlsson, president of KTH, opens the meeting.

- Prof. Yoshio Sone, University of Kyoto, *Fluid dynamics in the light of kinetic theory.* Inauguration of David Enskog lecture

- M.Sc. Mats Fridlund, History of Science and Technology, KTH, *The fall and rise of David Enskog*

- Prof. Alf Sjölander, CTH, *Liquids and dense gases - from Boltzmann- Chapman-Enskog to the present*

- Dr. Mikhail Dzugutov, KTH, *Enskog's ideas and atomic diffusion in liquids.*

7.4 Publications 1997

7.4.1 Published (and accepted) papers in archival journals and books

1. Alfredsson, P.H. 1997 Rotation and curvature effects on channel flows. *ERCOFTAC bulletin* **32**, 5–8.

2. Amberg, G. 1997 Parameter ranges in binary solidification from vertical boundaries. *Int. J. Heat Mass Transfer.* , **40**, 2565–2578.

3. Bech, K.H., Henningson, D.S. & Henkes, R.A.W.M. 1997 Linear and non-linear development of localized disturbances in zero and adverse pressure gradient boundary layers. To appear *Phys. Fluids.*

4. Dahlqvist, P. 1997 Decay of correlations, Lyapunov exponents and anomalous diffusion in the Sinai billiard, *J. Tech. Phys.* **38** 189 –194.

5. Dahlqvist, P. 1997 .The Lyapunov exponent in the Sinai billiard in the small scatterer limit. *Nonlinearity* **10** 159–173.

6. Dahlqvist, P. 1997 Computing topological pressure for intermittent maps, *J. Phys.* **A30**, L351–L358

7. Dahlqvist, P. 1997 On the effect of pruning on the singularity structure of zeta functions. *J. Math. Phys.* **38** 4273–4282

8. Dahlqvist, P. 1997 The role of singularities in chaotic spectroscopy. *Chaos, Solitons & Fractals* **8**1011–1097.

9. Dankowicz, H. 1997 Escape of Particles Orbiting Asteroids in the Presence of Radiation Pressure through Separatrix Splitting *Celes. Mech.* **67**(1) 63–85.

10. Dankowicz, H. 1997 Chaotic Dynamics in Hamiltonian Systems; with applications to celestial mechanics, *World Scientific Publishing Co. Pte. Ltd.*

11. Dankowicz, H. 1997, Dynamical Friction Modeling, in Computational Methods in Contact Mechanics III, ed. Aliabadi, M.H. , Samartin A. *Computational Mechanics Publications*, 227-236.

12. Elezgaray, J. , Berkooz, G. , Dankowicz, H. , Holmes, P. , Myers, M. 1997 Local Models and Large Scale Statistics of the Kuramoto-Sivashinsky Equation, in Multiscale Wavelet Methods For Partial Differential Equations, ed. Dahmen, W. , Kurdila, A. , Oswald, P. *Academic Press*, 441-471.

13. Essén H. 1997 Phase-space energy of charged particles with negligible radiation: Proof of spontaneous magnetic structures and new effective forces *Phys. Rev. E* **56** 5858–5865.

14. Lindgren, B., Österlund, J. & Johansson, A.V. 1997 Measurement and calculation of guide vane performance in expanding bends for wind-tunnels. *Exp. in Fluids.* **24** 265–272.

15. Nordström, J., Nordin, N. & Henningson, D.S. 1997 The Fringe Region Technique Used in the Direct Numerical Simulation of the Incompressible Navier-Stokes Equations. To appear *SIAM J. Sci. Comp.*

16. Olsson, M. and Fuchs, L. 1998 Large Eddy Simulation of a forced semi-confined circular impinging jet. *Phys. Fluids* **10**, 476–486.

17. Reddy, S., Schmid, P.J., Baggett, J.S. & Henningson, D.S. 1997 On stability of streamwise streaks and transition thresholds in plane channel flows. To appear *J. Fluid Mech.*

18. Thylwe, K.-E. & Dankowicz, H. 1997 Nonlinear phase-integral approximations of stationary waves in nonhomogeneous systems. *J. Phys. A: Math. Gen.* **30** 111–126.

19. Westin, K.J.A. & Henkes, R.A.W.M. 1997 Application of turbulence models to bypass transition. *J. Fluids Eng.* **119**, 859–866.

20. Zahrai, S., Bark, F. H. and Norman, B. 1997; An analysis of blade dewatering in a twin-wire paper machine. *Journal of Pulp and Paper Science* **23**, 452–459.

7.4.2 Published (and accepted) papers in conference proceedings

21. Alvelius, K, Hallbäck, M. & Johansson, A.V. 1997 LES of decaying turbulence using a spectral method implemented on parallel computers. In Proc. the First AFOSR International Conference on DNS/LES, Ruston, Louisiana August 1997, Ed. C. Liu. pp 499-506. Greyden Press, Columbus.

22. Alvelius, K., Hallbäck, M. & Johansson, A.V. 1997 Calibration of models for the slow pressure strain rate using LES. In Proc. of the eleventh Turbulent Shear Flows Conference, Grenoble Sept. 1997, pp P2-107 – P2-112.

23. Andersson, P., Berggren, M. & Henningson, D. 1997 Optimal disturbances in boundary layers. In Proc. of the A.F.O.S.R. workshop on optimal control and design, 30 Sept.–3 Oct. 1997. To appear in Birkhäser's *Progress in Systens and Control Theory* series.

24. Berggren, M. & Henkenschloss, M. 1997 Parallel solution of optimal-control problems by time-domain decomposition. *Computational Science for the 21st Century* (Ed. Bristeau, M-O. *et al.*), 102–112. Wiley.

25. Carlsson, C., Karlsson, G. & Olsen, B. 1997 Networked PBL; Teaching the Teacher on Flexible Learning. The Fourteenth International Conference on Technology and Education (ICTE'97), Oslo, Norway, August 1997, pp. 578-580. The International Conferences on Technology and Education, Arlington, Texas, USA, ISBN 0-9658957-1-8.

26. Carlsson, C., Karlsson, G. & Olsen, B. 1997 Networked PBL; Teaching the Teacher on Flexible Learning. Invited paper in Proc. of the 4th International Conference; Computer Aided Engineering Education (CAEE'97), Krakow, Poland, September 1997, Eds. M. Chrzanowski & E. Nawarecki. pp. I/1-I/4. Wydawnictwo "Akapit", Krakow, Poland, ISBN 83-7108-029-8.

27. Carlsson, C., Karlsson, G. & Olsen, B. 1997 Demonstration. Distance Course on the Design of Flexible Distance Training. Invited paper in Proc. of the 4th International Conference; Computer Aided Engineering Education (CAEE'97), Krakow, Poland, September 1997, Eds. M. Chrzanowski & E. Nawarecki. pp. I/5-I/6. Wydawnictwo "Akapit", Krakow, Poland, ISBN 83-7108-029-8.

28. Carlsson, C., Karlsson, G. & Olsen, B. 1997 Workshop. Distance Course on the Design of Flexible, Distance Training. Role of the Universities in the Future Inforamtion society (RUFIS'97), Prague, Czech Republic, September 1997, Eds. J. Hlavicka & K. Kveton. p. 97. CTU Publishing House, Prague.

29. Carlsson, C., Karlsson, G. & Olsen, B. 1997 Networked PBL: Teaching the Teacher on Flexible Learning. Role of the Universities in the Future Inforamtion society (RUFIS'97), Prague, Czech Republic, September 1997, Eds. J. Hlavicka & K. Kveton. pp. 197-200. CTU Publishing House, Prague.

30. Dahlkild, A.A. 1997 Hydrodynamic Diffusion Models of small Bubbles Produced at a Vertical Electrode inder Laminar Flow Conditions. Proceedings of 3rd Int. Conf. on Transfer Phenomena on Magnetohydrodynamic & Electroconducting Flows, Aussois - France, September 22-26.

31. Enflo, B.O. 1997 Sound beams with shockwave pulses. In Proceedings of the 20th Scandinavian Symposium on Physical Acoustics, Ustaoset, Norway, 2-5 February 1997, ed. by H Hobaek, Department of Physics, University of Bergen, Report 1997-4, 3-4.

32. Enflo, B.O. 1997 Sound beams with shockwave pulses. In Proceedings of the International Symposium on Hydroacoustics and Ultrasonics, EAA Symposium, Gdynia, Jurata, Poland, 12-16 May 1997, ed. by A. Stepnowski and E. Kozaczka, 75-78. Technical University of Gdansk.

33. Fukagata, K. Zahrai, S. & Bark, F.H. 1997; Large eddy simulation of particle motion in a turbulent channel flow. Proceedings of the 1997 ASME Fluid Engineering Division Summer Meeting, June 22-26, Vancouver, Canada.

34. Henkes, R.A.W.M., Skote, M. & Henningson, D.S. 1997 Application of turbulence models to equlibrium boundary layers under adverse pressure gradients. Proceedings from the Turbulent Shear Flow meeting Grenoble, September 1997.

35. Johansson, A.V. 1997 DNS & LES for turbulence and transition modelling. Invited paper in Proc. the First AFOSR International Conference on DNS/LES, Ruston, Louisiana August 1997, Ed. C. Liu. pp 149-152. Greyden Press, Columbus.

36. Komminaho, J., Lundbladh, A. & Johansson, A.V. 1997 Detarmination of the transitional Reynolds number in plane Couette flow through study of relaminarization. In Proc. the First AFOSR International Conference on DNS/LES, Ruston, Louisiana August 1997, Ed. C. Liu. pp 233-240. Greyden Press, Columbus.

37. Nyberg, C. 1997, Nonlinear Generation of Combination Frequencies in Closed Tubes. Proc. 14th International Symposium on Nonlinear Acoustics 1996, Ed. R. J.Wei pp 123–282. Nanjing University Press, Nanjing.

38. Olsson, M. and Fuchs, L. 1997 Amplified frequencies and SGS-models in the proximal region of a circular jet. in "Direct nand Large Eddy Simulatioon II". Eds. Chollet et al. pp. 23-34. Kluwer.

39. Olsson, P.J. and Fuchs, L. 1998 The interaction of spherical particles. Proc. of ECCOMAS. to be appear in September 1998.

40. Parsheh, M. & Dahlkild, A.A. 1997 Numerical modeling of mixing in a stratified headbox jet. Proceedings of TAPPI Eng. Conf., Oct 6-9, Nashville, USA.

41. Söderberg, L. D. & Alfredsson, P. H. 1997; Experiments concerning the creation of streaky structures inside a plane water jet. Proceedings of TAPPI Engng. conf, Oct. 6-9, Nashville, USA.

42. Söderholm, L.H. 1997 13 Moments Equations Based on First-Order Chapman-Enskog Solution. Rarefied Gas Dynamics 20, Ed. C. Shen pp 124-127. Peking University Press, Beijing. (Proceedings of the 20th International Symposium on Rarefied Gas Dynamics, Beijing, China, August 1996.)

43. Wallin, S. & Johansson, A.V. 1997 A new explicit algebraic Reynolds stress turbulence model for 3D flow. In Proc. of the Eleventh Symposium on Turbulent Shear Flows, Grenoble, Sept. 1997, pp 13-13 – 13-17.

44. Wikström, P., Johansson, A.V. & Hallbäck, M. 1997 Measurement and modeling of heat flux transport in a heated cylinder wake. In Proc. of the eleventh Turbulent Shear Flows Conference, Grenoble Sept. 1997.

45. Winkler, C., Amberg, G., Inoue, H, and Koseki, T. 1997 A Numerical and Experimental Investigation of Qualitatively Different Weld Pool Shapes, in Mathematical Modelling of Weld Phenomena 4, Eds. H. Cerjak, H.K.D.H. Bhadeshia Institute of Materials, London, in press.

7.4.3 Technical reports and preprints

46. Alvelius, K.1997 Large Eddy Simulation of Homogeneous Turbulence. *Licentiate thesis, Mechanics Dept., KTH.* TRITA-MEK Technical Report 1997:12.

47. Adolfsson, J.1997 A study of stability in autobalancing systems using multiple correction masses. *Licentiate thesis, Mechanics Dept., KTH.* TRITA-MEK Technical Report 1997:3.

48. Dahlqvist, P & Vattay, G. 1997 Periodic orbit quantization of the Sinai billiard in the small scatterer limit, submitted to *J Phys* **A**.

49. Dettmann, C.P. and Dahlqvist, P. 1997, Computing the diffusion coefficients for intermittent maps - Resummation of stability ordered cycle expansions , submitted to *Phys. Rev.* **E**.

50. Ekdahl, G. 1997 The Mechanics of Overhead Railroad Electrification Systems. TRITA-MEK Technical Report 1997:15.

51. Elofsson, P.A., Kawakami, M. & Alfredsson, P.H. 1997 Experiments on the stability of streamwise streaks in plane Poiseuille flow. Submitted to *Phys. Fluids*.

52. Fukagata, K. 1997 Large Eddy Simulation of Particulate Turbulent Channel Flows. *Licentiate thesis, Mechanics Dept., KTH.* TRITA-MEK TR 1997:11.

53. Fukagata, K. Zahrai, S. & Bark, F.H. 1997; Large eddy simulation of particle motion in a turbulent channel flow. Submitted to Int. J. Engng. Sci. .

54. Fukagata, K. Zahrai, S. & Bark, F.H. 1997; Force balance in a turbulent particulate channel flow. Submitted to Int. J. Multiphase Flow.

55. Grönland, T-A. 1997 A study of Hypersonic Afterbody Flow Fields. Licentiate thesis, KTH, Stockholm, TRITA-MEK Technical Report 1997:4.

56. Gurbatov, S.N., Enflo, B.O. & Pasmanik, G.V. 1997 The decay of pulses with complex structure according to Burgers' equation, TRITA-PDC Report 1996:14.

57. Hildings, C. 1997 Simulation of laminar and transitional separation bubbles. TRITA-MEK TR 1997:19 (Licentiate thesis)

58. Johansson, B 1997 On generation of polygonal-shaped shock waves-experimental studies. FFA TN 1997-51. Also TRITA-MEK TR 97:13.

59. Kawakami, M., Elofsson, P. & Alfredsson, H. 1997 Experiments on the stability of streaks in plane Poiseuille flow. TRITA-MEK TR 1997:16.

60. Lavalley, R. 1997 Experimental and Numerical Investigation of Thermocapillary Instabilities. TRITA-MEK TR 1997:20 (Licentiate thesis)

61. Nigam, M. S. and Bark, F. H. 1997; An analytocal Method to Calculate the Flow Past a Blade in Twin-Wire Formers. TRITA-MEK Technical Report 1997:7.

62. Olsson, M. 1997 Large-eddy simulation of turbulent jets. TRITA-MEK Technical Report 1997:2, *Doctoral thesis, Mechanics Dept., KTH.*

63. Sjögren, T. 1997 Development and calibration of turbulence models through experiment and computation. TRITA-MEK Technical Report 1997:5, *Doctoral thesis, Mechanics Dept., KTH.*

64. Sundström, L.-G. 1997 Studies on mass transfer in electrochemical systems. TRITA-MEK Technical Report 1997:17, *Doctoral thesis, Mechanics Dept., KTH.*

65. Söderberg, D. 1997 Experimental and Theoretical Studeies of Plane Liquid Jets. TRITA-MEK Technical Report 1997:1, *Licentiate thesis, Mechanics Dept., KTH.*

66. Tehranian, S. 1997 Flameholding Configurations for Kerosene Combustion in a Mach 1.8 Airflow, TRITA-MEK 97-18.

67. Thor, A.J. 1997 Harmonization between ISO 31 and IEC 27. *ISO Bulletin 9/97.*

68. Tönhardt, R. , Amberg, G. 1997 Phasefield Simulation of Dendritic Growth in a Shear Flow. *J. Crystal Growth.* Submitted.

69. Wallin, S & Johansson, A.V. 1997 A complete explicit algebraic Reynolds stress model for incompressible and compressible turbulent flows. FFA TN 1997-51.

70. Wallin, S, Wikström, P.M. & Johansson, A.V. 1997 Explicit algebraic modelling of passive scalar flux. FFA TN 1997-52.

71. Westin, J. 1997 Laminar-turbulent boundary layer transition influenced by free stream turbulence. TRITA-MEK Technical Report 1997:10, *Doctoral thesis, Mechanics Dept., KTH.*

72. Widlund, O., Zahrai, S. and Bark, F. 1997; On MHD Turbulence Models for Simulation of Magnetic Brakes in Continuous Steel Casting Processes. Presented at 3rd PAMIR Conf. on Transfer Phenomena in Magnetohydrodynamic & Electroconducting Flows, Aussois - France, 22-26b Sept. Full length manuscript to be published in book form in autumn 1998.

73. Wolz, U., Palme, J., Anderson, P., Chen, Z., Dunne, J., Karlsson, G., Laribi, A., Männikkö, S., Spielvogel, R., & Walker, H., Computer-Mediated Communication in Collaborative Educational Settings, ITiCSE'97 Working Group Reports and Supplemental Proceedings 1997 ACM 1-58113-012-0/97/0010. pp. 51-68.

74. Zahrai, Sima 1997 On the fluid mechanics of twin-wire formers. TRITA-MEK Technical Report 1997:14, *Doctoral thesis, Mechanics Dept., KTH.*

75. Zahrai, S., Bark, F. H. and Martinez, D. M. 1997; A numerical study of cake formation in 2D cross-flow filtration. Submitted to the Journal of Pulp and Paper Science.

7.5 Seminars

Two series of regular seminars have been given during 1997, namely *'Fikaseminarier' – a fluid mechanics seminar series* (coordinated by E. Lindborg) and *Theoretical and Applied Mechanics seminar series* (coordinated by L. Söderholm). The seminars given in these together with those of invited speakers, given at the department, are listed below.

January 15, 1997 Agne Swerin, STFI:
Fibersuspensioners rheologi

January 28 Dr. Jonas Larsson, Department of Physics, Umeå University:
A generalization of the modified Hamilton's principle

February 12 Prof. Torbjörn Hellsten, Fusion Plasma Physics, Alfvén Laboratory, KTH:
Status of Fusion Research

February 19 Mats Fredriksson, Dept. of Mech., KTH:
Turbulence the Hopf Way

February 26 Lars-Göran Sundström, Dept. of Mech., KTH:
Flame Studies

March 5 Robert Tönhardt, Dept. of Mech., KTH:
Pattern Formation in Systems of Reaction-Diffusion Equations

March 12 Martin Skote, Dept. of Mech., KTH:
Measuring the dimension of climatic and weather attractors

March 24 Prof. Joel Ferziger, Stanford Univ.:
Large Eddy Simulation of Flow over a Cube attached to a Channel Wall

April 3 Michael Vynnycky, Dept. of Mech., KTH:
Buoyant-thermocapillary instabilities of differentially heated liquid layers

April 16 Dr. Fredrik Wallinder, Dept. of Science anTechnology, Univ. of Örebro:
The central engine in compact astronomical sources

April 18 Jean-Francois Mercier, Service de Physique Theorique, CEA/Saclay, France:
Buoyant-thermocapillary instabilities of differentially heated liquid layers

April 24 Sven-Olof Enfors, Biokemisk teknologi, KTH:
Strömningsmekaniska tillämpningar inom biotekniken

May 10 Prof. Edwin Kreuzer, Ocean Engineering II, Technical University, Hamburg-Harburg:
Dynamics and stability in offshore engineering

May 21 Dr. Andreas Bette, Danderyds Matematikgymnasium and Department of Physics, University of Stockholm :
Twistor Phase Space Dynamics

May 23 Prof. Dr.-Ing. Shinnosuke Obi Department of Mechanical Engineering, Keio University, Yokohama, Japan:

Optical Measurement of Local Skin Friction Using a Laser Gradient Meter

May 29 Dr. F. N. Shaikh Engineering Department Queen Mary and Westfield College University of London:
The latter stages of boundary layer transition

May 29 Prof. K. S. Breuer Dept. of Aeronautics & Astronautics Massachusetts Institute of Technology:
Active Control of Turbulent Boundary Layers

May 30 Prof. John Kim, UCLA:
Taming Turbulence

June 6 Dr Gad Hetsroni, Technion, Haifa:
Two-Phase Flow and Heat Transfer

June 11 Dr Franz Rosenberger, CMMR, University of Huntsville, Alabama:
Real-time Radiotracer diffusion measurement technique

June 12 Prof. Marius Ungarish, Technion, Haifa:
Magnetic Spin-up in a Liquid Metal

June 13 Dr Franz Rosenberger, CMMR, University of Huntsville, Alabama:
Numerical simulations of the convective contamination of diffusivity measurements in liquids

June 16 Prof. Peyman Givi Department of Mechanical and Aerospace Engineering State University of New York Buffalo:
Filtered Density Function for Large Eddy Simulation of Turbulent Reacting Flows

June 18 Prof. Kazuo Aoki, Dept Areonautics and Astronautics, Kyoto University:
A study of vapour flows condensing on a plane condensed phase on the basis of kinetic theory

September 19 Dr. Carl Dettman, Niels Bohr Institute, Copenhagen:
The Lorentz Gas: from chaos to statistical mechanics

September 23 Professor Yoshio Sone, Department of Aeronautics and Astronautics, Kyoto University:
Fluid dynamics in the light of kinetic theory (Inauguration of David Enskog lecture)

September 23 Mats Fridlund, Dept History of Science and Technology, KTH:
The fall and rise of David Enskog

September 23 Prof. Alf Sjölander, Chalmers University of Technology, Gothenburg:
Liquids and dense gases - from Boltzmann-Chapman-Enskog to the present

September 23 Dr. Mikhail Dzugutov, Parallel Computing Center, KTH:
Enskog's ideas and atomic diffusion in liquids (Together these four lectures comprise "The Enskog Heritage" in commemoration of the 50th anniversary of the death of David Enskog, Professor of Mathematics and Mechanics at KTH)

September 24 Professor S.C. Gupta, Indian Institute of Science, Bangalore:
Analytical and numerical solutions of multi-dimensional solidification/melting problems

September 26 Professor Yoshio Sone, Department of Aeronautics and Astronautics, Kyoto University:
Asymptotic theory of the Boltzmann equation for small Knudsen number

October 8 Professor Andy Ruina TAM, Cornell University:
The McGeer Passive-Dynamic Walking Program

October 9 Erik Lindborg, Dept. of Mech., KTH:
'Determining the atmospheric energy cascade'

October 16 Joe Haritonidis, Ohio State Univ.:
'Transition control using neural networks'

October 23 Ola Vidlund, Dept. of Mech., KTH:
'Modelling of magnetohydrodynamic (MHD) turbulence'

October 30 Sima Zahrai, Dept. of Mech., KTH:
'On the fluid mechanics of twin wire formes'

November 4 Carlo Casciola, Uviversity of Rome "La Sapienza":
'Transient responce to harmonic excitation in Poiseuille flows'

November 6 Per Elofson, Dept. of Mech., KTH:
'Oblique transition and streek instability'

November 12 Dr. Anders Bodare, Soil and Rock Mechanics, KTH:
Ground Vibrations from High Speed Trains

November13 Petra Wikström, Dept. of Mech., KTH:
'DNS and modelling of passive scalar flux in turbulent channel flow'

November 19 Anders Lennartsson :
New developments of Sophia, the Maple toolbox for dynamics of multibody systems, and its application to the bicycle

November 26 Prof. Zbigniew Peradzynski, Institute of Fundamental Technological Research, Polish Academy of Sciences, Warsaw:
Propagation of second sound pulses in superfluid helium (Burgers approximation)

November 27 Casper Hildings, Dept. of Mech., KTH:
'Transition in separation bubbles'

December 3 Dr. Göran Rehbinder, Hydraulic Engineering, KTH:
Flexural stresses in the earth's crust due to a meteorite impact

December 4 Stellan Berlin, Dept. of Mech., KTH:
'Oblique boundary layer transition'

December 10 Per Olsson, Dept. of Mech., KTH:
Influence of small spherical particles on a flow governed by Navier-Stokes' equations

December 11 Peter Yakubenko, Dept. of Hydralic eng., KTH:
'Over-reflection and shear instability in shallow water'

December 17 Hanno Essén, Dept. of Mech., KTH:
Theoretical Evidence for a Phase Transition among Conduction Electrons due to their Magnetic Interaction

7.6 Presentations by staff during the period July 1995 – Dec. 1996

Listed below are presentations by staff members where conference papers (or similar) were not published (coauthors are given within parenthesis)

J. Adolfsson (and A. Lennartsson) *Mechanical Simulator of the Vasa Whipstaff.* Presentation at Teknikhistoriska Dagar 11-12 May 1998, Swedish Royal Academy of Science.

P.H. Alfredsson *Free stream turbulence and transient growth in boundary layer flows.* Invited talk at 3rd European Fluid Mechanics Conference, Sept. 1997 Göttingen.

G. Amberg*Oscillatory Thermocapillary Convection in Half-Zones and Similar Geometries* seminar presented at University of Pennsylvania, University of Arizona and Stanford University, January 1997.

A.A. Bakchinov, C.P. Häggmark, P.H. Alfredsson, C. Hildings & D.S. Henningson *Experimental and numerical study of a transitional two-dimensional separation bubble.* Presented at the Annual Meeting of the Divsion of Fluid Dynamics, APS, Nov. 1997, San Fransisco.

H. Dankowicz
Dynamic Friction Modeling presented at:

- Univ. of Pennsylvania, Dept. of Mechanical Engineering and Applied Mechanics, Philadelphia, Pennsylvania, USA
- Univ. of Colorado at Boulder, Dept. of Mechanical Engineering, Boulder, Colorado, USA
- Linkoping's Technical Institute, Dept. of Mechanics, Linkoping
- Technical Univ. of Denmark, Dept. of Mathematical Modelling, Lyngby, Denmark
- Swedish Mechanics Days, Lulea, Sweden
- The Fourth SIAM Conference on Applications of Dynamical Systems, Snowbird, Utah, USA
- Contact Mechanics 1997, Madrid, Spain
- 3rd EUROMECH Solid Mechanics Conference 1997, Stockholm, Sweden

Evolving Control Strategies for Suppressing Heteroclinic Bursting in the Turbulent Boundary Layer presented at:

- Univ. of Maryland at College Park, Dept. of Mechanical Engineering, College Park, Maryland, USA.

G. Ekdahl (and A. Lennartsson) *Experiment and simulations of a scaled model pantograph.* Oral presentation at the 3rd Euromech Solid Mechanics Conference, KTH Stockholm, August 18-27 1997.

G. Ekdahl *Regalskeppet Vasas styrsystem: Rekonstruktion, modell och experiment.* Presentation at Teknikhistoriska Dagar 11-12 May 1998, Swedish Royal Academy of Science.

P.A. Elofsson & P.H.Alfredsson *Oblique transition and streak instability in Blasius boundary layer flow.* Presented at the Annual Meeting of the Divsion of Fluid Dynamics, APS, Nov. 1997, San Fransisco.

H. Essén *Hopprepskurvan (The Skipping Rope Curve)* Presented at the Swedish Mechanics Days, March 1997, Luleå.

M. Fredriksson (and A. Nordmark) *Bifurcations caused by grazing incidence in many degree of freedom impact oscillators.* Euromech 375 “Biology and Technology of Walking”, München.

J. Gunnarsson *Modelling strongly rotating channel flow with an automated CFD-code generator.* Presentation at the 3rd European Euromech Fluid Dynamics Conf., Göttingen - Germany.

G. Karlsson *FLIP - Flexible Learning in Physics and Mechanics* Presented at the UNESCO-CICT Workshop on Inforamtion Technology in Education and Research, March 1997, Mumbai (Bombay), India.

B.Olsen and G. Karlsson G. *FLIP - Flexible Learning in Physics and Mechanics* Presented at the lexible Learning on the Information SuperHighway (FLISH'97), May 1997, Sheffield, UK.

R. Carlsson, G. Karlsson and B. Olsen *Networked PBL; Teaching the Teacher on Flexible Learning* Presented at the Conference on Integrating Technology into Computer Science Education ITiSCE'97, June 1997, Uppsala, Sweden.

M. Lesser (coauthored by T. Wright and G. Eriksson) *The mechanics of the Vasa Steering Mechanism.* Oral presentation at the 3rd Euromech Solid Mechanics Conference, KTH Stockholm, August 1997.

M. Lesser *The Helmsman's Enigma.* Gustav Adolfsdagen Presentation at the Vasa Museum, Stockholm, November 6th 1997.

M. Lesser *Mechanics as a Key to History, The Vasa Whipstaff.* Presentation at Teknikhistoriska Dagar 11-12 May 1998, Swedish Royal Academy of Science.

A. Nordmark *Unidirectinal spin and nonholonomic dynamics.* Oral presentation at the 3rd Euromech Solid Mechanics Conference, KTH Stockholm, August 18-27 1997.

L. Söderholm. *13 Moments Equations Based on First Order Chapman-Enskog Solution.* Presented at the 15th International Conference on Transport Theory, Gothenburg, June 1997.

K.-E. Thylwe *On the time-dependent normal form Hamiltonians* Presented at the Dept. Mathematics, KTH, Stockholm in Feb. 1997.

R. Tönhardt *Simulation of dendritic growth in a shear flow.* Presented at Conference on Dynamics of mixed phase regions, June 1997, Edinburgh.

C. Winkler *A Numerical and Experimental Investigation of Qualitatively Different Weld Pool Shapes.* Presented at 4th International Seminar on Numerical Analysis of Weldability, Graz-Seggau, Austria, October 1997.

7.7 Visiting scientists

Carl. P Dettmann, Niels Bohr Institute, Copenhagen, September 1997 (two weeks).

Prof. Z. Peradzynski, Institute of Fundamental Technological Research, Polish Academy of Sciences, Warsaw, Poland, Nov. - Dec. 1997 (2 weeks).

Prof. Peter Schmid, Department of Applied Mathematics, University of Washington, Seattle. Sep. 1997 (1 month).

Dr. Carlo Casiola, Department of Mechanics and Aerodautics, University of Rome, Oct. 1997 (2 weeks).

Prof. Joe Haritonidis, Ohio State Univ., Sept.-Dec. (3 months)

Professor Yoshio Sone, Department of Aeornautics and Astronautics, Kyoto University, September 1997 (1 week).

Dr. Michael Vynnycky, Tohoku National Industrial Research Institute, Sendai, Japan, Jan-dec. 1997 (12 months).

PhD-student Michael Katasonov, Institute of Theoretical and Applied Mechanics, Russian Academy of Sciences, Novosibirsk, Russia, Dec. 1997-Feb. 1998 (3 months)

Prof. Alessandro Talamelli, Dipartimento di Ingegneria Aerospaziale, Universita' di Pisa, Italy, Aug.-Sept. 1997 (6 weeks)

Dr. Masaharau Matsubara, Tohoku University, Sendai May - Aug 97

PhD-student Mitsyuoshi Kawakami, Tohoku University, Sendai, Aug 96 - Aug 97.

shorter visits (less than 1 week) to the department by:

– Prof. A. Ruina, Dept. of Theoretical and Applied Mechanics, Cornell University, Itahca, New York, USA.
– Prof. A. Alemany, LEGI, INPG, Grenoble.
– Prof. S.C. Gupta, Department of Mathematics, Indian Institute of Science, Bangalore, India, 22-24 September 1997.
– Professor Kazuo Aoki, Department of Aeornautics and Astronautics, Kyoto University, June 1997.
– Dr. Rebecca Lingwood, Department of Engineering, University of Cambridge
– Prof. Nick Trefethen, Oxford University
– Prof. John Kim, UCLA
– Dr F. N. Shaikh, Engineering Department, Queen Mary and Westfield College London
– Prof. Kenneth Breuer, MIT, Cambridge, USA

7.8 Visits abroad by staff ($>$ 2 weeks)

Henrik Alfredsson visited Tohoku University Sendai twice during 1997 totaling 4 weeks, and EPFL, Lausanne for 2 weeks.

8 Other activities

Henrik Alfredsson
- sabbatical leave, Jan-June, visiting Tohoku University, Sendai and EPFL, Lausanne
- dean of Faculty of Engineering Physics, July-Dec
- chairman of Swedish National Committee for Mechanics
- reviewer for J. Fluid Mech., Phys. Fluids, Eur. J. Mech. B/Fluids
- made two appearances in the TV-program “Hjärnkontoret” to explain a) the conservation of energy using a ski slope, b) the flight of the boomerang.

Gustav Amberg
- 100 % financing from KTH ('rörlig resurs').
- reviewer for J. Fluid Mech., Powder Technology, Physics of Fluids, AIAA/ASME joint Conf.
- Secretary of the Swedish National Committee for Mechanics (SNM)
- Visits to University of Pennsylvania, University of Arizona, Stanford University. January 1997. Presented seminars at all three places.
- Visited Nippon Steel research laboratories, and Tohoku University, Japan, July 1997. Presented seminars at Nippon Steel.

Nicholas Apazidis
- Referee for: Int. J. Multiphase Flow, International Journal of Heat and Fluid Flow
- Opponent at the PhD thesis: Flow and clogging mechanisms in porous media with applications to dams. Martinet, P., KTH 1998
- Awards: The annual teacher of the year prize for the academic year 96/97 by the students at the School of Physics, KTH
- Advisor for Bo Johansson

Fritz Bark
- acted as director of the Faxén Laboratory, see separate report.
- acted on two PhD evaluation committees ('betygsnämnder')
- member of the scientific committee for the 3rd International Conference on Transfer Phenomena in Magnetohydrodynamic and Electroconducting Flows, September 1997 in Aussois, France.
- member of the editorial board of ZAMP.

Anthony Burden
- KTH coordinator of the Erasmus network Resau STAR 2000

Ian Cohen
- Participated in the organization of and was session chairman at ISSAC '97 Hawaii.

Anders Dahlkild
- involved in the continued development of a course in fluid mechanics for graduate students.
- reviewed manuscripts for Physics of Fluids
- member of Hans Enwalds PhD examination committee at Chalmers on Dec 12

- involved in the FaxénLaboratory, 'Kompetenscentrum Processteknisk Strömningsmekanik vid KTH'.

Per Dahlqvist
- Three day visit at NORDITA, Copenhagen, November 1997.
- Member of "Censorkorpset for Fysik", Denmark.
- Reviewed manuscripts for J.Phys **A**. and Phys.Lett.**A**.

Bengt Enflo
- reviewer for an adjoint professorship in technical acoustics , KTH, Jan. 1997
- evaluator EU-programme TMR (Training and mobility of researchers) Apr. 1997
- member of the Scientific Committee of the International Symposium on Hydroacoustics and Ultrasonics, Jurata, Poland 12-16 May 1997
- Research visit with presentation of a seminar at Department of Radiophysics, State University of Nizhny Novgorod, Russia, 14-22 Dec. 1997

Hanno Essén
- 50 % financing from KTH LUFT resources.
- study rector at the department
- shares the advisorship for Anders Lennartsson with Martin Lesser
- advisor for Gunnar Maxe
- referee for several journal manuscripts
- vice chairman for 'Föreningen Vetenskap och Folkbildning'

Dan Henningson
- coordinator of the Swedish ERCOFTAC Pilot Center
- member of ERCOFTAC Managing Board and Scientific Program Committee
- member of the European Turbulence Committee, which is part of the EUROMECH organization and serves as organizing committee of the European Turbulence Conferences
- reviewer for J. of Fluid Mech., Phys. Fluids, Theor. Comp. Fluid Mech., Appl. Sci. Res., J. Eng. Math.

Arne Johansson
- head of department
- member of the Board of Directors of KTH.
- vice chairman of 'Centrala Fakultetskollegiet' of KTH.
- member of the Advisory Board for the European Journal of Mechanics/B – Fluids
- member of the Scientific Committee of Second International Conference on DNS and LES, to be held in Louisiana August 1997.
- member of the Advisory board for the conference series Turbulent Shear Flow Phenomena, the first conference to be held in Santa Barbara (USA) September 1999.
- Served on a search committe for a professorship at Chalmers.
- reviewed manuscripts for J. Fluid Mech., Physics of Fluids, European Journal of Mechanics B/Fluids.
- served on the FAKIR group at KTH.
- served on 'It-Rådet' KTH.
- served on 'kvalitetsrådet' at KTH.

Göran Karlsson

- Member of Program and Coordination Committees for the conferences:
  CALISCE'98, G&oteborg June 15 -19, 1998
  CAEE'97, Krakow September 11 - 13, 1997
  RUFIS'97, Prague September 25 - 27, 1997
  RUFIS'98, Monterrey, Mexico July 22 - 24, 1998
- Member of editorial board for European Journal of Engineering Education
- Member of SEFI's (European Society for Engineering Eduction) working groups for Computer Aided Engineering Education and for Physics
- Engaged by UNESCO Physics Action Council Working Group 2 Telecommunications Networks for Science for Internet connectivity for the Mumbai region, India

Rolf Karlsson

- Member of the Scientific Program Committee and the Industrial Advisory Committee of ERCOFTAC.
- Member of the Organising Committe of the ERCOFTAC/IAHR/COST Workshop on Refined Flow Modelling, held in Delft June 1997.
- Chairman of the board of "Faxén Laboratory".
- Chairman of the Swedish LDA Association.
- Member of the Scientific Committe of the Conference of Laser Anemometry - Advances and Applications, held in Karlsruhe Sept 1997. Reviewer of papers for the conference.
- Member of the Advisory Committee of the 9th Int. Symp. on Applications of Laser Techniques to Fluid Mechanics, to be held in Lisbon July 1998.
- Gave seminars on 3-component LDV measurement techniques at Tokyo University and Keio University, April 1997
- Reviewer for Exp.Fluids.
- Member of grade committee for a PhD dissertation

Martin Lesser

- Reviewer for Lecturer Position at Cambridge University Dept. of Physics. Lecturer Position. Technical University of Lund, Mechanics. Reader Position at Imperial College Mechanical Engineering Department.
- associate Editor of J. of Bifurcation and Chaos
- reviewer for Proc. Roy. Soc. of London, J. Bifurcation and Chaos,
- served on the Scientific Committee of 3rd Euromech Solid Mechanics Conference
- member of the Swedish National Committee for Mechanics
- served on TFR proposal evaluation committee chaired by Prof. H. Gustavsson.
- member of the Faculty of Engineering Physics Appointment Committee.
- Elected Member of the board of CISM, Udine Italy.
- served on the TFY committee for the Göran Gustafsson Foundation.

Arne Nordmark

- reviewer for Int. J. of Bifurcation and Chaos., Proc. of the Royal Soc. of London

Christer Nyberg

- 25 % financing from KTH LUFT resources.

Lars Söderholm
• Together with Nicholas Apazidis arranged a mini-symposium, 'The Enskog Heritage', September 1997. Four speakers were invited, see list of seminars. Suppported by the Nobel Committee of Physics.
• Written second edition of compendium 'Mechanics and Thermodynamics of Continua'.
• Reviewer for Earth, Moon and Planets
• Member of grading committee of theoretical physics dissertation at KTH October 1997.

Anders Thor
• Secretary of ISO/12, Quantities, units, symbols, conversion factors.
• Secretary of ISO/TC 203, Technical energy systems.
• Chairman of IEC/TC 25, Quantities, units, and their letter symbols.

9 The Faxén Laboratory

A short description of the Faxén Laboratory is given below for the period July 1997 – June 1998. The text in section is an extract (with some modifications) of the separate activity report for the Faxén Laboratory written by Anders Dahlkild. The mechanics department is the 'host' department for the Faxén Laboratory (web address: http://www.mech.kth.se/faxenlab).

9.1 Introduction

The Faxén Laboratory, below referred to as FLA, is a NUTEK competence centre with the goal of making research results and methods in experimental, numerical and theoretical fluid mechanics easily available for the participating industrial partners. It is also a goal to broaden the multidisciplinary knowledge base of fluid mechanics in industrial process technology by means of a research program leading to Licentiate and Doctoral degrees. The costs of this centre are shared equally between KTH, NUTEK, and the following parties from industry:

ABB Corporate Research
ABB Industrial Systems
ABB Switchgear
AGA AB
Albany Nordiskafilt AB
Alfa-Laval Separation AB
Assi-Domän AB
Avesta Sheffield AB
Eka Chemicals AB
Korsnäs AB
MoDo AB
Outokumpu Copper Partners AB
Permascand AB
SCA
SKF ERC
Stora Corporate Research
Valmet Corporation
Vattenfall Utveckling AB (The Vattenfall Development Co.)
Volvo Car Corporation Components AB

The following financiers are contributing as 'non-signatory' partners: Bo Ax:son Johnson Foundation, Bo Rydin Foundation, Institut Polytechnique de Grenoble (via an agreement of cooperation with KTH), NUTEK (via a contract not included in the Three-party Contract), Swedish Pulp & Paper Research Foundation

Staff from the following departments of KTH are involved in the activities of FLA:

Alfvénlaboratoriet (ALF)
Dept. of Chemical Engineering & Technology
Dept. of Materials Processing
Dept. of Mechanics

Dept. of Pulp and Paper Chemistry & Technology

The inter-disciplinary character of the work at FLA is well illustrated by the names of these departments. Thus they represent no less than three of the different Schools at KTH - Chemistry & Chemical Engineering, Mechanical & Materials Engineering, and Engineering Physics.

9.2 Management and organisation of the Centre

Major decisions about the activities of FLA are made by its Board. The present members of this are: Ann Cornell, Lic.Eng., Eka Chemicals AB, Torsten Holm, MSc, AGA AB, Rolf Karlsson, Professor, Vattenfall Utveckling AB (Chairman), Ivars Neretnieks, Professor, Dept. of Chemical Engineering, KTH, Björn Widell, Professor, ABB Industrial Systems Anders Wigsten, PhD, Stora Corporate Research

The operative leadership at FLA consists of the following persons:
Professor Fritz Bark, Dept. of Mechanics, KTH – Director
PhD Anders Dahlkild, Dept. of Mechanics, KTH - Scientific secretary
PhD Michael Vynnycky, Dept. of Mechanics, KTH - Scientific coordinator

Administration of the Centre is handled by:
Ingunn Wester, Dept. of Mechanics, KTH - administrative head.

The research efforts of Faxén Laboratory are aimed at these three main areas:

Electrochemistry
Materials processing
Paper technology

9.3 Research performed at Faxén Laboratory

Relevant publications are listed in section 7.4. The Faxén Laboratory arranged a number of seminars listed in section 7.5.

9.3.1 Electrochemical engineering

Participating bodies from industry: ABB Corporate Research, Avesta Sheffield AB, EKA Chemicals AB, Permascand AB, Vattenfall Utveckling AB.

Other party: Institut Polytechnique de Grenoble.

General description:
Electrolysis takes place in baths of electrolyte in so called electrolysers, in which a number of electrodes are immersed, either connected in series or in parallel. Due to the reactions at the electrodes the concentration field varies in space, with the result that the electrolytes weight (per unit volume) will be locally either less or more than the average weight in the bath. Consequently the electrolyte is set in motion by the force of gravity. This motion is nearly always turbulent. Furthermore, in e.g. the production of sodium chlorate, hydrogen gas is generated at the cathode

and in the zinc electro-winning process, oxygen gas is evolved also at the anode. Due to drag force between the bubbles and the electrolyte, the upward motion of the bubbles of gas causes turbulent circulation of the electrolyte in the reactor.

Many problems which are closely related to the fluid mechanical phenomena mentioned above, are highly relevant for optimisation of the design of electrolysers. For instance, the exchange of mass at the electrodes should be maximized, which requires a rapid supply of undepleted electrolyte. However, high velocities result in short residence times in the electrolysers, which leads to a lot of electrolyte passing through the electrolyser without being fully used. The development of gas bubbles at the electrodes is often exploited to drive the electrolyte through the electrolyser, but at the same time a large volume fraction of bubbles increases the electrical resistance of the electrolyte, which increases the Ohmic loss of energy. Today, the consumption of energy is perhaps the most critical problem in the electro-chemical process industry.

Projects:

Contracted projects:

I:1 Turbulent free convection in large cells.
Computing turbulent convection in electrochemical cells
- Researcher: François Gurniki - advisor: Said Zahrai.
Measurement of turbulent ranges in free convection.
- Researcher: Johan Persson - advisor: Rolf Karlsson.

I:2 Gas-evolving electrodes.
Computing the two-phase flow in gas-evolving, electrochemical cells.
- Researcher: Ruben Wedin - advisors: Anders Dahlkild, Fritz Bark.
Experiments involving systems of electrodes developing gas
- Researchers: Philip Byrne - advisors: Daniel Simonsson, Ed Fontes.
- Senior researcher: Patrick Boisonneau

I:3 Pickling of steel.
Modelling of electrolytic pickling.
- Researcher: Nulifer Ipek - advisors: Noam Lior, Michael Vynnycky.

Externally financed projects:

I:4 Modelling of bubbly two-phase flow in nuclear fuel reactors/ ABB CRC
-Researcher: Ulrike Windecker, ABB CRC - advisor: Said Zahrai

I:5 Mass transfer in chemically reacting systems/ ABB CRC
- Researcher: Peter Löfgren - advisor: Said Zahrai

Cooperation schemes with companies:
i) Avesta Sheffield AB, Eka Chemicals AB and Vattenfall Utveckling AB are represented in the guidance group.

ii) Philip Byrnes's experimental setup of electrodes developing gas will is completed by Permascand AB, and the first experiments will be carried out at the Eka Chemicals plant in Sundsvall. LDV equipment for measurements will be supplied by Vattenfall Utveckling AB.

iii) Johan Persson, doctoral student at FLA, is 50% employed by Vattenfall Utveckling AB.

iv) Electrodes for the small scale cell-experiment of % Patrick Boissonneau were supplied by Permascand AB

v) Said Zahari, ABB Corporate Research, is supervising three of the research students active in this programme.

vi) Ed Fontes, Eka Chemicals AB, is assisting advisor of Philip Byrne

Guest researcher:
PhD Patrick Boissonneau 971201-980715, I:2 Prof Noam Lior 970701-980630, I:3

9.3.2 Materials processing

Participating bodies from industry: ABB Corporate Research, ABB Industrial Systems, ABB Switchgear, AGA AB Outokumpu Copper Partner AB, SKF ERC, Volvo Personvagnar Komponenter AB.

Other party: Bo Ax:son Johnson Foundation.

General description:
In continuous casting of metals the molten material or melt is supplied continuously through a cooling annulus, the mould. Solidification first takes place at the rim of the melt, forming a shell in contact with the mould. The solidification continues outside the mould, gradually building up a thicker shell until the whole cross section is solid metal. The quality of the steel and structure of the metal surface depends to a great extent on the flow of the melt in the mould. Due to the turbulent motion caused by the violent filling process, slag material at the upper surface of the melt is easily mixed into the melt, contaminating the final product with small inclusions. One way of reducing this contamination is to use a so-called electromagnetic brake, by which a magnetic field is used to calm down the turbulent motion. The surface structure of the final product is dependent on the flow in the neighbourhood of the contact line at the mould between molten and solidified material. The poorly understood interplay between the solidification process, surface tension, gravity and forces induced by the flow is now being investigated.

In the mechanical engineering industry heat treatment is a central process in the manufacture of high-performance components such as bearings, gears and sledge-hammers. These products obtain their mechanical properties as a result of the phase changes which take place during coo-ling (quenching or hardening) after heat treatment. The activities of the Centre concerning hardening of steel will be carried out in collaboration with the Swedish Institute for Metals Research at which theoretical and experimental research is being carried out under the supervision of the Technical Council of the Swedish Mechanical Engineering Industry. Also the Brinell centre for metallurgical research will participate in these efforts. In the Faxén Laboratory, realistic computational methods will be developed for the heat transfer between component and cooling gas. These methods will complement the existing simulation models for the transport of heat, the phase changes and the mechanical response, i.e. rest stresses and deformation, within the component. The resulting computational model will consti-tute both a unique and a powerful tool for controlling hardening processes.

Projects:

Contracted projects:

II:1 Modelling of MHD-turbulence
Electromagnetic braking in continuous casting; modelling of turbulence
- Researcher: Ola Widlund - advisor: Said Zahrai.

II:2 Stability of contact lines
Early stage solidification in Continuous casting process
- Researcher: Jessica Elfstrand - advisor: Hasse Fredriksson.

II:3 Continuous casting of copper alloys.
Modelling of fluid flow, heat flow and solidification in a strip caster
- Researcher: Jafar Mahmoudi - advisor: Hasse Fredriksson, Michael Vynnycky.

II:4 Quenching of steel Numerical simulation of a gas quenching chamber
- Researcher: Jerome Ferrari - advisor: Noam Lior
Gas cooling for hardening steel
- Researcher: Mats Lind - advisor: Noam Lior

II:5 Simulation of turbulent flow with particles
LES-simulation of turbulent channel flow with particles
- Researcher: Koji Fukagata - advisor: Said Zahrai.

II:6 Material changes when braking large currents
Ablation controlled arcs in circuit breakers
- Researcher: Torbjörn Nielsen - advisor: Said Zahrai

II:7 Modelling of turbulence at small Rossby numbers
- Researcher: Jonas Gunnarsson - advisor: Arne Johanson

II:8 Numerical modelling of liquid metal flow with a free surface
- Researcher: Mats Larsson - advisor: Torbjörn Hellsten, Jin Lee

Externally financed projects:

II:9 Flow in heat exchangers/ ABB CRC
- Researcher: Johan Palm - advisor: Said Zahrai

Cooperation schemes with companies:
i) ABB Industrial Systems, AGA AB and SKF ERC are represented in the guidance group.

ii) Koji Fukagata QUEST, University of Tokyo and FLA is working for his PhD within the FaxénLaboratoriet programme while employed in Tokyo.

iii) Said Zahrai of ABB Corporate Research is working 20% of his time at FLA, supervising Koji Fukagata and Ola Widlund by spending one day a week at KTH.

iv) In the course of his AGA AB project Mats Lind is in contact with the Project group for low-pollution hardening at the Swedish Institute of Production Engineering Research. Besides AGA AB this group includes Ovako Steel AB, UGAB, Volvo PV AB Transmission, Sandvik Rock Tools

AB, SKF Sweden AB and Scania AB.

v) At ABB Industrial Systems a trip to the USA is being planned for Ola Widlund and James Centerstam so they can take part in the start-up of an electromagnetic brake.

vi) Torbjörn Nielsen has his office at ABB CRC and make use of their computer system.

vii) Mats Larsson spends much of his time at ABB ISY where Jin Lee acts as his assisting supervisor.

viii) Jonas Gunnarsson spends part-time at Alfa-Laval and performs his experimental work there.

9.3.3 Paper technology

Participating bodies from industry: Assi Domän AB,lbany Nordiskafilt AB, Assi Domän AB, Korsnäs AB, MoDo AB/R&D, SCA Research AB, Stora Corporate Research AB, Valmet Corporation.

Other parties: NUTEK, Bo Rydin Foundation, Swedish Pulp & Paper Research Foundation.

General description:
In a paper-making machine a suspension of cellulose fibres is turned into a wet mat of fibre by squirting out most of the water. In traditional forming, most of the water is squirted out of the suspension on a moving horizontal filtering net, a so called 'wire'. The suspension is transferred to the wire by the means of a thin but broad jet from a 'head box'. The water is then sucked out of the suspension through the wire. However, there are a number of drawbacks in this method. Hydrodynamic instabilities in the interface between the suspension and the air above it will limit the speed at which the process can take place. Furthermore, one-sided de-watering makes the structure of the surface of the paper different on its two sides, which is most inconvenient in he case of for instance printing paper.

These disadvantages can be eliminated to a great extent in modern twin-wire machines. In these the jet from the head box is directed into the space between two almost parallel wires, which are kept close together and at high tension. The pair of wires is then passed over one or more rol-lers or blades which makes the separation between the stream lines increase due to the centrifu-gal force. This leads to an increase in the pressure, which drives the water out of the suspen-sion. This method works reasonably well in actual operation, but the understanding of its basic mechanics is far from complete. A better understanding will almost certainly lead to considerable improve-ments in the method. Basically the quality of the final product, measured by homogeneity and the iso-tropy of the fibres, is determined by the flow in the head box and the flow on and between the wires.

Projects:

Contracted projects:

III:1 The dynamics of plane free jets
Experimental and theoretical studies of the stability of flat beams
- Researcher: Daniel Söderberg - advisor: Henrik Alfredsson

III:2 Forming between two wires Numerical models for the flow at twin wire forming
- Researcher: Sima Zahrai - advisor: Fritz Bark
Mathematical models for dewatering during twin wire forming

- Researcher: Nicolas Moch - advisor: Fritz Bark

III:3 The influence of fibres on dewatering between two wires
Computing the flow of a wire nip
- Researcher: Gerald Audenis - advisor: Anders Dahlkild

III:4 Fibre suspensions in contractions Analysis of the orientation of fibres in a headbox
- Researcher: Mats Ullmar - advisor: Bo Norman

III:5 Flow in stratified head boxes Computing the flow of a stratified headbox
- Researcher: Mehran Parsheh - advisor: Anders Dahlkild

Cooperation schemes with companies:
i) STORA, SCA and Valmet Corporation have two representatives in the guidance group.

ii) Projects at STORA in both Falun and Skoghall are planned to be carried out with doctoral students taking an active part.

iii) Mats Ullmar, Sima Zahrai and Nicolas Moch are in constant touch with the Swedish Pulp & Paper Research Institute, and the cost of running the FEX machine on their behalf is borne by the industries taking part in the projects.

9.4 Economics

The turnover during 1997 reached 12 MSEK.

The total cash (in MSEK) contributions for 1997 from the three major parties amount to:

KTH	2.3
Industry	1.7
NUTEK	4
Σ	8

Also in-kind contributions totalling roughly 4MSEK (according to budget) from industryand KTH add to the total budget.

9.5 Personnel

The following abbreviations are used for KTH departments and companies:
K (Chemical technology), M (Mechanics), MP (Materials processing), PM (Paper & pulp technology, ABB CRC (ABB Corporate Research), VUAB (Vattenfall Utveckling AB).

Research students:

Electrochemistry: Philip Byrne (K), François Gurniki (M), Nulifer Ipek (M), Peter Löfgren (ABB CRC) Johan Persson (M, VUAB), Ruben Wedin (M) Ulrike Windecker (ABB CRC)

Materials processing: Jessica Elfstrand (MP), Jerome Ferrari (M), Koji Fukagata (University of

Tokyo), Jonas Gunnarsson (M), Mats Larsson (ALF), Mats Lind (M), Jafar Mahmoudi (MP), Torbjörn Nielsen (M), Johan Palm (ABB CRC), Ola Widlund (M)

Paper technology: Gerald Audenis (M), Nicolas Moch (M), Mehran Parsheh (M), Daniel Söderberg (M), Mats Ullmar (PM), Sima Zahrai (M)

9.6 Miscellaneous

International efforts

Faxén Laboratory is a member of two international organisations, viz:
- European Research Community on Flow Turbulence and Combustion (ERCOFTAC)
- International Association for Hydromagnetic Phenomena and Applications (HYDROMAG)

In the autumn of 1996 the Swedish Pulp & Paper Research Institute, in a joint project with Faxén Laboratory, started a so-called COST Action aimed at the subject of forming in paper machines, etc.

Late in 1996, in a joint project with Institut Polytechnique de Grenoble and a number of other European research institutes and universities, Faxén Laboratory filed a revised application for funds from the EU programme of "Training and Mobility of Researchers". The specific aim is to bring about exchanges of post-doctorships for the purpose of theoretical and experimental studies of transportation in electrochemical systems.

Application to the Swedish Foundation for Stategic Research (SSF)

In the spring of 1997 an application for funds towards planning the formation of a national centre for theoretical and experimental studies of multiphase flows was approved by the SSF. A final application for funds have jointly benn forwarded to SSF by the Faxén Laboratory, the Centre for Bio-Process Technology (Professor S.-O. Enfors), Parallel Scientific Computing (Professor B. Engqvist) and the Dept. of Thermo- and Fluid Dynamics at CTH in Gothenburg (Dr. A.-E. Almstedt). In the course of preparation of the final application representatives of the different parties and others met on May 21-22, 1997 at Billingehus in Skövde to discuss the content. The final application has been reviewed by the working group at SFF and also by international expertise. A possible decision for funding by the SSF board can bee expected during the autumn 1998.

Newsletter

A monthly newsletter from Faxén Laboratory has been circulated since March 1996 via Internet and by post. The contents usually cover dates of seminars, meetings and internal work-shops, travel reports and various information about the activities.

Conferences arranged by the FaxénLaboratoriet:

Dalarö April 27-28, 1998: FPIRC/FLA-work shop on paper technology A overview of ongoing paper technological research projects in Sweden were presented and discussed. Participants: Bo Norman, Tom Lindström, Staffan Toll, Jesper Oppelstrup, Ulf Björkman, Mark Martinez, Sven Andersson, Johan Ringner, Thomas Wikström, Agne Swerin, Luciano Beghello, Daniel Sohlberg, Mats Ullmar, Daniel Söderberg, Mehran Parsheh, Gerald Audenis, Marco Lucisano, Anders Dahlkild, Martin Jansson, Staffan Lundström, Hannes Vomhoff, Mårten Alkhagen, Jan- Erik Gustavsson, Katarina Gustavsson, Björn Fransson, Janne Laine, Lars Martinsson, Björn Nilsson, Bengt Nordström, Henry Ottosson, Mikael Rigdahl.

Attendance at courses and conferences outside KTH:

- Göttingen Sept 15-18, 1997: 3rd EUROMECH Fluid Mechanics Conference. Contribution to the agenda from FaxénLab. by J. Gunnarsson; Modelling strongly rotating channel flow with an automated CFD- code generator.

- Aussois Sept 22-26, 1997: 3rd PAMIR Conference on Transfer phenomena in magnetohydrodynamic & electroconducting flows. Contribution to the agenda from FaxénLab. by Widlund, O., Zahrai, S. and Bark, F. H. ; Development of a Reynolds stress closure for modelling of homogeneous MHD turbulence, Byrne, P., Simonsson, D., Fontes E. and Didier, L.; A Model of the Anode from the Chlorate cell Dahlkild, A.A. ; Hydrodynamic Diffusion Models of small Bubbles Produced at a Vertical Electrode under Laminar Flow Conditions.

- Nashville October 6-9, 1997: TAPPI Engng. conf Contributions to the agenda from FaxénLab. by Ullmar, M. and Norman B. 1997; Observation of fibre orientation in a headbox nozzle at low consistency. Söderberg, L. D. and Alfredsson, P. H. 1997; Experiments concerning the creation of streaky structures inside a plane water jet. Parsheh, M. and Dahlkild, A.A. 1997; Numerical modelling of mixing in a stratified headbox jet.

- Paris October 8-19, 1997: ERCOFTAC-meeting Participant from FaxénLab. was Rolf Karlsson, Vattenfall Utveckling AB

- Chilton March 26-27, 1998: CFX-course at AEA-technology Participants from FaxénLab were Michael Vynnycky, Nulifer Ipek and Jafar Mahmoudi.

- Frankfurt April 1-2, 1998: Work-shop on magnetic fields in metals casting; collaboration between industry and academia Participant from FaxénLab. was Ola Widlund

- Chilton May 1, 1998: CFX-course at AEA-technology Participant from FaxénLab was Jerome Ferrari

The academic year 1997 - 1998 at Faxén Laboratory; examples of events:

- Altogether 13 guidance/working group meetings for the different areas were held at KTH and at the participating industries.

- Sept 15: Visit to FaxénLab from Mechanical Wood-Pulps Network in Canada.

- Sept 16-17: The FaxénLaboratoriet Annual Meeting 1997 in Sundsvall organised by SCA and Eka Chemicals AB.

- October 13: Visit to Christian Doppler Laboratorium, TU Wien

- October 17: Visit to FaxénLab from Austrian Research Centre Seibersdorf and Austrian Federal Ministry for Science and Transportation.

- February 4: Visit by Profs André Tess and Oleg Zikanov, TU Dresden

- April 27-28: FPIRC/FLA workshop in paper technology