Department of Mechanics

KTH, SE-100 44 Stockholm, Sweden

Activity Report 1998

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 sixth budget year of the (new) department of mechanics in education, research and other areas.

Stockholm, March 1999

Arne Johansson, department chairman
Martin Lesser, department vice chairman

1 Introduction

This is the sixth annual activity report of the new mechanics department and covers the year 1998. The mechanics department (web address: http://www.mech.kth.se) has 82 employees and a yearly turnaround of about 40 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 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), Fredrik Lundell (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 45 graduate students active at the department (13 of which are associated with the Faxén Laboratory) and 9 external graduate students in industry and research institutes. Five doctoral degrees and five licentiate degrees were awarded during 1998.

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

A new wind-tunnel was inaugurated on October 22 with approximately 60 persons from the department as well as from industry, FFA, Chalmers and Luleå University of Technology. Arne Johansson has been the project leader and Björn Lindgren has been responsible for most parts of the design and many other aspects.

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

Personel related matters

Dan Henningson who until November 1998 has been 'adjungerad prof.' was employed as a Senior Lecturer ('Universitetslektor') Dec. 1, 1998.

10 new graduate students started during 1998.

Dr Said Zaharai and Dr Harry Dankowicz obtained the degree of 'oavlönad docent' in May and June, respectively.

Prof. Fritz Bark was on sabbatical leave during fall 1998.

Harry Dankowicz received a Junior Individual Grant from SSF (500 kSEK annualy for three years).

Hans Silverhag började som ekonomiadministratör på FLA/mekanik mars 1998.

Lars-Göran Sundström died August 21, 1998 during a research visit in Grenoble.

Department meetings and miscellaneous

The department board met on February 18, September 2 and December 9, 1998.

A department meeting with Christmas dinner was held December 15, 1998 at Lovik.

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), Lars Bjernerstam (ATF) (until 980731) 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.

A popular science description of the research activities at the department has been put together by Harry Dankowicz and is now part of the so called SAFARI web-pages of KTH.

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. Dean of Engineering Physics

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 semiclassical 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

Michael Vynnycky, PhD Univ. of Oxford, Lecturer at Univ. of East Anglia, Norwich 1991-92, Extended research visits in Japan 1992-96, at KTH from 1997.

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.

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 (intendent)	Marcus Gällstedt
Ulf Landén	Lillemor Lindbom (chefsadm./intendent)	Anne-Mari Olofsson
Hans Silverhag	Jan Ströman	Ingunn Wester (chefsadm./intendent)

Professors emeritii

Bengt-Joel Andersson
Sune Berndt
Olof Brulin
Stig Hjalmars

Graduate students (in Swedish: doktorander)

Jesper Adolfsson
Krister Alvelius
Kristian Angele
Paul Andersson (also at FFA)
Gerald Audenis (FLA)
Stellan Berlin
Erik Birgersson (FLA)
Karl Borg
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
Fredrik Lundell
Per Olsson
Mehran Parsheh (FLA)
Ivan Pavlov
Petri Piiroinen
Jan Pralits
Henrik Sandqvist
Mikael Sima
Martin Skote
Daniel Söderberg (FLA)
Tadahisa Terao
Robert Tönhardt
Ruben Wedin (FLA)
Ola Widlund (FLA)
Petra Wikström
Christian Winkler

Tom Wright
Naoki Yoshida
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
Peter Löfgren (FLA) ABB Corp. Res.
Hans Moberg, Alfa Laval, Tumba
Hans Mårtensson. Volvo Aero Corporation in Trollhättan.
Torbjörn Nielsen (FLA) ABB Corp. Res.
Johan Persson (FLA) Vattenfall Utveckling AB
Roland Rydén. Volvo Aero Corporation in Trollhättan.
Lars Thysell, FFA
Stefan Wallin, FFA
Ulrike Windecker (FLA) ABB Corp. Res.

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 $\times$ 0.8 m) test section, max. speed 69 m/s
- Subsonic wind-tunnel, 0.4 m $\times$ 0.5 m test section, max. speed 50 m/s
- New subsonic wind-tunnel (1998), 0.5 m $\times$ 0.75 m test section, max. speed 48 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 separation and turbulence structure.

A smaller windtunnel based on the same concept as the MTL-tunnel was inaugurated in october 98. The new windtunnel will be used both in research and education. The tunnel is powered by a frequency controlled 15 kW AC-motor and has expanding corners ($\frac{A_{out}}{A_{in}} = 1.32$) to be able to reduce the overall length.

The department also has access to a continuously running supersonic wind-tunnel, 0.1m$\times$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 apparatus 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$\times$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 separation of 1 ms, and a processing unit for crosscorrelation of the two images. The system (laser and camera) runs at a frequency of 15 Hz.

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

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
- Digital video camera recorder
- Smoke generators both for flow visualisation and particle generation in PIV and LDV.

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, (>)55 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 are responsible for maintaining the departments web pages.

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 it's own AFS cell and Kerberos realm. There is 54 GB of disk storage in the AFS filesystem distributed on six 9GB disks with two wide SCSI controlers on each server. 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 it also acts as a printer server for the PC's using Samba.

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 is also two SUN Ultra2's shared by the department. One called dom for for interactive jobs and one called ask for batch jobs.

A significant amount of computer time has also been granted to some of the research groups within the department from international supercomputer centers.

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 1998. The incoming resources to the Faxén Laboratory are not included here. These amount to roughly 9 MSEK for 1998 (excluding in-kind contributions). The Faxén Laboratory is described separately in section 9.

<u>INCOME</u>

	Dept. total
Education (GRU)	**8.7**
Research (FOFU)	**13.0**
External	**11.2**
Σ	**32.9**

The external funding is mainly composed of grants from TFR, NUTEK, The Göran Gustafsson Foundation and NFR. The total of 32.9 MSEK for 1998 may be compared with a total of 37.7 Mkr for 1997. The decrease in income for all the three sectors caused significant economic problems for this budget year.

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). A substantial amount of material is also handed out / made available in the form of course notes, problem sets etc. to complement the book of Meriam and Kraige. Parts of this material is made available in the form of web-pages.

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 following is a list of undergraduate courses given during 1998, here given with Swedish names (english translations given within parenthesis).

Grundkurser (basic courses)

Studieinriktn. *School*	*Läsår* *Year*	*Nummer* *Course no.*	*Poäng* *Credit*	*Namn* *Name*
I,M,T,V	1	5C1103	6	Mekanik, baskurs (Mech. basic course)
B,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	4	5C1205	4	Kompressibel strömning, ak, (Compressible flow, general course)
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	5C1125	2	Mekanikens matematiska metoder, fk (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	4	5C1208	2	Strömningsmekanik, fk (Fluid Mechanics, Advanced Course)
F, M, T	4	5C1209	2	Kompressibel strömning, fk (Compressible flow, advanced course)
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	5C1210	4	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 and D. Henningson), Experimental methods in fluid mechanics (N. Tillmark 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.

98/01 Holmqvist, Claes, Sedimentation in a Container with a Cylindrically Curved Wall (A. Dahlkild) TRITA-MEK 98-03

98/02 Holst, Clas, Active Damping of Carbody Vibrations (L. Söderholm)

98/03 Angele, Kristian, Flameholding of Hydrogen in Supersonic Airflow (H. Alfredsson)

98/04 Klevebring, Fredrik, and Nilsson, Mikael, A Study of Aerodynamics of Low Reynolds Number Airfoils (L. Söderholm)

98/05 Möller, Joakim, The Plane Kirchoff Formulation, with Application to the Noise from a Turbulent Boundary Layer (D. Henningson)

98/06 Borg, Karl, Effects of Nonlinear Reaction Kinetics on Electrolyte Convection in a Porous Separator (F. Bark)

98/07 Gustavsson, Jonas, Experiments on Flow Separation (B. Muhammad Klingmann)

98/08 Ohlson, Örjan, Experimentell studie av skottets uppförande i slamlock i centrifugalseparatorer (H. Alfredsson)

98/09 Choi, Donghee, Geometric Conservation Laws for Computational Moving Boundary and Complex Geometry Problems (L. Fuchs)

98/10 Dahlberg, Urban, Modellering och simulering av en pneumatisk mjölkningsrobot (H. Dankowicz)

98/11 Lindgren, Niclas, A Computional Fluid Dynamics Study of Laminar Under-expanded Jet (H. Alfredsson)

98/12 Sjöberg, Johanna, An Experimental Study and Wavelet Analysis of a Wing Tip Vortex (H. Alfredsson)

98/13 Taeby, Kurosh, Stability and Control of a Thermal Loop (H. Alfredsson)

98/14 Ekblom, Anna and Gullman-Strand, Johan Experimental Study of Compressible Flow with Friction and Heat Addition (H. Alfredsson)

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: 21

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: 6,7,64,65,79

Dynamics of Hamiltonian systems with applications to celestial mechanics

Researcher: Harry Dankowicz

Sponsor:

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 and other stability properties.

Dynamical models of friction

Researchers: Harry Dankowicz, Arne Nordmark

Sponsor: SSF, 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: 9,10,72

Human and machine locomotion

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

Sponsor: SSF, TFR, Volvo Research Foundation

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.

Publications: 73

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.

Publications: 71,74

Propagation and diffraction of sound in fluids

Researchers: Bengt Enflo, Claes Hedberg (University of Karlskrona/Ronneby), Sergey Gurbatov (Nizhny Novgorod), Oleg Rudenko (Moscow), Zbigniew Peradzynski (Warsaw)

Sponsor: TFR, KVA, Göran Gustafsson's Stiftelse

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 nonlinear propagation of sonic boom waves.

Publications: 13

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.

Publications: 42,52

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.

Publications: 43,50

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: 15,16,67

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*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.

Theoretical acoustical investigations with applications in musical acoustics

Researcher: Christer Nyberg

Sponsor: KTH

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: 26

Dynamics of Moderately and Highly Rarefied Gases

Researcher: Lars Söderholm; *Graduate students*: Karl Borg & Naoki Yoshida.

Sponsor: LUFT, TFR

The dynamics of gases is studied in two regions. Firstly, the region where characteristic lengths are larger than but approach the mean free path. In air at normal conditions, this is the case for flow in channels of diameter of the order of 10^{-4} mm, say. The Burnett equations are reformulated as perturbed Navier-Stokes equation, avoiding instabilities. Moment equations are modified to give a well-defined range of validity in terms of mean free path.

Secondly, the dynamics of gases is also studied in the free molecular flow limit of characteristic length small compared with mean free path. In particular, the effects of the non-Maxwellian character of the distribution function is considered for the transfer of momentum (thermophoresis) and heat to nonspherical bodies. The influence of wall roughness on the heat exchange of a rarefied gas flow in narrow channels is an example.

Publications: 32,82

Relativity, Non-linear Waves and Integrability

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

Sponsor: LUFT.

An equation for nonlinear acoustics is derived from the compressible Navier-Stokes equations. It is exact in the Mach number and correct to order $1/Reynoldsnumber$. Terms of the order of $Machnumber/Reynoldsnumber$ are neglected. When the Mach number is of the order of the inverse Reynolds number, the derived equation reduces to the well-known Kuznetsov equation.

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 recently obtained 13 moments equations correct to first order in the Knudsen number are extended to relativistic conditions. All modes propagate as waves. A new generalized Fermi derivative is introduced, which turns out to be an appropriate tool for formulating dissipative gas dynamics equations.

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.

Publications: 39,81,83,90

Semiclassical Mechanics

Researchers: K.-E. Thylwe, in collaboration with Prof H.-J. Korsch (Kaiserslautern, Germany) and Prof J. N. L. Connor (Manchester, UK).

Sponsor: NFR, 'Rörlig resurs, KTH'.

In order to understand details of atoms and molecules interacting with external fields, it is essential to understand the underlying classical theory of time-dependent Hamiltonian systems. Theoretical research in this area is of basic importance for interpreting and predicting a growing body of experimental data obtained by the most sophisticated experiments. The semiclassical research topics include: * New time-dependent normal forms for resonant dynamics. The usual semiclassical theory of tunnelling through chaotic separatrix regions, resulting in the splitting of degenerate quasi energies, gives merely a rough estimate of the spectrum and would benefit from a more detailed level of approximation. * A unified complex angular momentum theory for scattering models used in analysing spectra of quantized biliard systems. This would clarify the identification of classical and non-classical (ghost) contributions. * The development of new semiclassical approximations for field switching in single and more-dimensional states. These provide an understanding of non-adiabatic effects beyond the perturbation theory and provide transparent link between transition probabilities and switching profiles in quantum optics models.

Publications: 33,34

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, Fredrik Lundell, Masaharu Matsubara, Alessandro Talamelli, Nils Tillmark, Johan Westin

Sponsors: TFR, KVA, Göran Gustafsson stiftelse.

This project deals with the transition to turbulence in laminar boundary layers, and various methods 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. This research was included in the doctoral thesis of Elofsson, which was succesfully defended in May 1998.

An new experiment has been designed in order to model the streaky structures which are seen in the boundary layer flows and then to develop active control methods. This model experiment uses a channel where the streaks are formed through regularly spaced suction holes and where secondary instability can be forced. Tests show that this set-up mimicks many of the features of free stream turbulence induced transition and preliminary control experiments are underway. Control will be applied through local (in time and space) suction/blowing at the wall.

Transition often occur when a laminar boundary layer separates. One project deals with this type of transition in the MTL-tunnel, where a pressure gradient is imposed by an adjustable bump mounted at the upper wall, forcing separation at the test 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 the separated region.

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. A correction method was deviced and it was also found that by intentionally separate the wires it is possible to determine some correlations which otherwise cannot be measured with traditional hot-wire configurations.

In cases where body forces affect boundary layer flows 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. 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 and LDV measurements are underway to study plane Couette flow both in the rotating and non-rotating cases.

Publications: 3,11,12,25,36,48,55,63,66,75,76,84

Hydrodynamics of plane liquid jets

Researchers: Daniel Söderberg, Henrik Alfredsson

Sponsors: FaxénLaboratoriet

In modern paper manufacturing, a plane liquid jet is used to distribute the fibre suspension in a paper machine. It is believed that the homogeneity of the jet flow is of vital importance to obtain a good quality paper.

Theoretical and experimental investigations of the behaviour of plane water jet have been performed. The numerical solution of the basic flow field and stability equations have been compared to experimental results. The experiments show the presence of two-dimensional spanwise homogenous waves, travelling in the streamwise direction of the jet. In connection with these waves, a strong break-up of the jet could be observed. These waves could only be observed with a channel nozzle, which gives a flow dominated by viscosity. A stability investigation of the basic flow field gave results which correlated well with the experimental results.

In January and November 1998 visualisations of an industrial headbox jet were performed at STFI using high-speed video. In the first test three different configurations of the headbox were tested, two with separation vanes and one without. The visualisations were performed with both water and a fibre suspension. The visualisations showed waves similar to the instability waves found in the channel flow jet. In the second experimental series visualizations of a multi-layered headbox jet were performed using layers with different colours. This allows for an insight in the degree of mixing between different layers. The visualizations were complemented by forming actual paper sheets. By comparing the images captured at the headbox and the final paper sheets, it is possible to determine the overall influence of the headbox flow.

Publications: 31

Modelling of solidification in materials processing

Researchers: Gustav Amberg, Robert Tönhardt

Sponsors: TFR, KTH (rörlig resurs, LUFT).

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.

Publications: 35,60,86,87

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: 59,77,78

Modelling of magnetohydrodynamic (MHD) turbulence

Researchers: Fritz Bark, Ola Widlund, Said Zahrai

Sponsors: FaxénLaboratoriet

Electrostatic magnetic fields are used in continuous casting of steel to brake and control the mean flow of liquid metal in the mould. The magnetic field also causes magnetic Joule dissipation of turbulence, thus affecting turbulent transport of heat and mass. Numerical simulations of this and other turbulent magnetohydrodynamic (MHD) flows suffer from the inability of conventional turbulence models to deal with the large anisotropies of length scales in MHD turbulence. The objective of the project is to develop an extended Reynolds-stress closure suitable for modelling of MHD turbulence in engineering applications. The extended closure includes structural information, which is shown to be vital for a correct description of MHD turbulence.

Publications: 37

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.

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.

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.

Control of low-dimensional models of the turbulent boundary layer

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

Sponsor:

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.

Publications: 8

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, other ”asymptotic” SGS models (such as the “Exact Differential Model (EDM)”) 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.

Supporting LIF measurements of the turbulent mixing in an impinging jet has also been carried out. The effects of different SGS models on the mixing has been compared with experiments.

Publications: 18,28,51

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 and moving solid spheres and the surrounding fluid. Due to the presence of attracting and repelling forces that depend on the geometrical configurations, one can expect an intensive and complex motion of the particles when they are allowed to move freely. Due to this effect simple rheological (isotropic) models are inadequate.

Publications: 49

Boundary layer transition – Theory and DNS

Researchers: Dan Henningson, Stellan Berlin, Casper Hildings, Luca Brandt

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 nonlinearity 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: 4,5,29,61,62

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.

Publications: 20

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. The later stages of transition induced by high free-stream turbulence levels have been studied using secondary stability analysis.

Publications: 1,2,19,70

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 super 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 boundary layers in adverse pressure gradients.

In the project we simulate turbulent boundary layers for a number of flow cases including adverse pressure gradients 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.

Optimal design of vehicles with low drag

Researchers: Jan Pralits, Ardeshir Hanifi, Dan Henningson, Martin Berggren

Sponsors: SSF/IVS

The project aims at developing methodology needed for optimal design of vehicles with low drag. The general objective is to link aerodynamic computational tools with optimization techniques to create a more automated flow design process in order to improve flow efficiency. The sensitivity of the predicted drag, say, on the design parameters chosen can then effectively be determined by the use of so called adjoint methods. The aim is to automatically incorporate a transition prediction method into the design process of low-drag vehicles. This chosen problem should be seen as one interesting example where these optimal design methods can be applied. The techniques developed in the project are general and once mastered could be applied in a number of other design applications.

Measurement, modelling and simulation of turbulence

Researchers: A.V. Johansson, K. Alvelius, F. Gregoire, T. Hambraeus, T. Terao, 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. Especially the modelling of the inter-component transfer terms have been studied and models for the pressure strain-rate have been proposed.

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. In conjunction with this modelling work also a DNS study of turbulent channel flow with heat transfer has been carried out. 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 also a direct numerical simulation study for various rates of system rotation has recently been finished.

The construction of a new wind-tunnel has recently been finished. Together with the MTL tunnel it will be a primary experimental tool 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:

- the first direct experimental determination of slow and rapid pressure strain-rate
- new versatile, interactive tools for testing and calibration of turbulence models with ongoing work for general 2D-geometries.
- new explicit algebraic models for the Reynolds stress tensor and the passive scalar flux vector
- new simulations of rotating channel flow and channel flow with heat transfer
- a new forcing method to obtain stationary homogeneous turbulence in simulations

Publications: 30,38,46,57,58,88,89

Numerical simulation of turbulent pipe flow

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 algebra involved is quite severe. Some finer details of the code development remain and results from actual computations of turbulent pipe flow are planned to be presented in June 1999.

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 have recently been carried out.

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 was inaugurated in October 1998 and is presently being calibrated in terms of flow quality etc. 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.

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.

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 published in Exp. Fluids. This experiment has also been used as a test case at the ERCOF-

TAC/IAHR Workshop on Refined Flow Modelling, Paris April 1996 and in Delft June 1997.

Together with Prof. W.K. George, USA, and a group at Chalmers Univ. of Technology, the work on a similarity theory of the plane wall jet is just concluded, and a paper will be submitted.

Publications: 14

Two-dimensional turbulence 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.

Publications: 23,24

Investigation of turbulent flow separation using PIV

Researchers: Barbro Muhammad-Klingmann, Graduate students: Kristian Angele, Gabriel Usera (Montevideo, Uruguay), Undergraduate student: Jonas Gustavsson

Sponsors: TFR.

Flow separation occurs as a result of a sudden or gradual rise in pressure over the surface of a body such as lifting wings, blading in turbomachinery or diffuser walls. In most cases flow separation causes a severe reduction in the performance of the flow device of interest.

The objective of the present project is is twofold, addressing both basic physical phenomena and measurement technique. Studies have been undertaken one of the department's low speed wind-tunnels, equipped with a transparent flat plate model and an adjustable ceiling with a convergent-divergent shape. In this setup a pressure gradient is created on a flat surface, thus facilitating the measurement process. The boundary layer development has been studied under varying pressure gradients using traditional measurement techniques (hot wire and LDV), and data have been obtained which can be used for validation of turbulence models. A similar setup is presently being prepared in a somwhat larger windtunnel with a 4m long test section. Future studies in this new wind tunnel will be directed towards passive control of separation. Such control methods include free stream turbulence (which is known to have a mitigating effect on flow separation), as well as different means of inducing longitudinal vortices in the boundary layer.

A novel aspect is the introduction of PIV (Particle Image Velocimetry) which allows accurate velocity measurement, while simultaneously obtaining a visual picture of the flow field. An example is shown in figure 1. PIV promises to become a tool powerful tool, particularly in reverse flow fields, where e.g. hotwire techniques fail. The flow field is illuminated by a pulsed Nd:YAG laser, and recorded by a high resolution double image CCD camera. This technique is on the front line of experimental fluid dynamics, and it is of capital interest to extend its capabilities. In contrast to previous studies of this kind, we are as a standard working with large data sets (400 - 4000 image pairs), allowing to compute reliable turbulence statistics. One study addressing the capacity of PIV to resolve the structure of turbulent boundary layer was recently performed in the MTL wind tunnel, where attention was directed towards obtaining maximum optical quality. Another line of work is to improve PIV processing algorithms. In the example shown in figure 2, an iterative technique has been used to gradually refine the detail of the measurement. This technique makes it possible to increase the spatial resolution beyond the nominal capacity of the equipment, making it possible to identify and analyze turbulent structures.

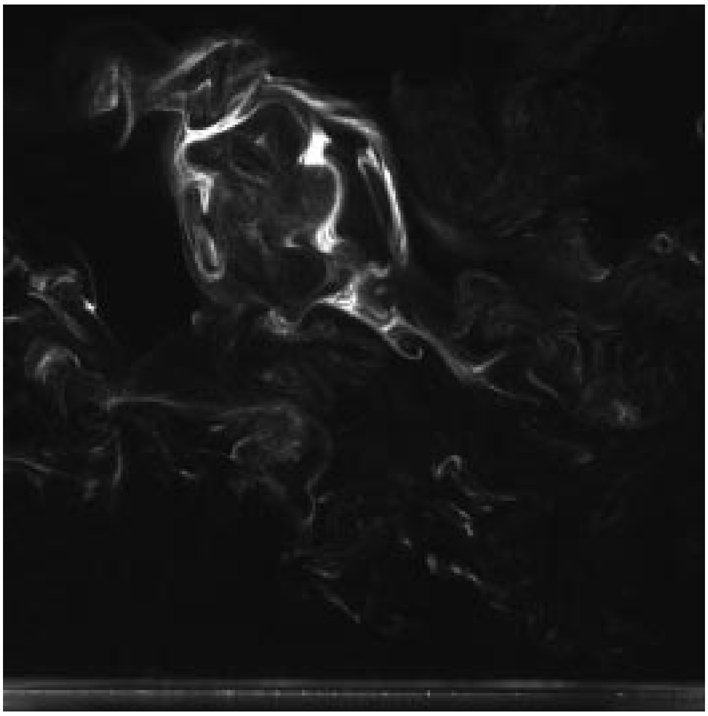

Figure 1: Visualisation of turbulent structure in a zero press. grad. boundary layer at $Re \approx 1.0 \times 10^6$

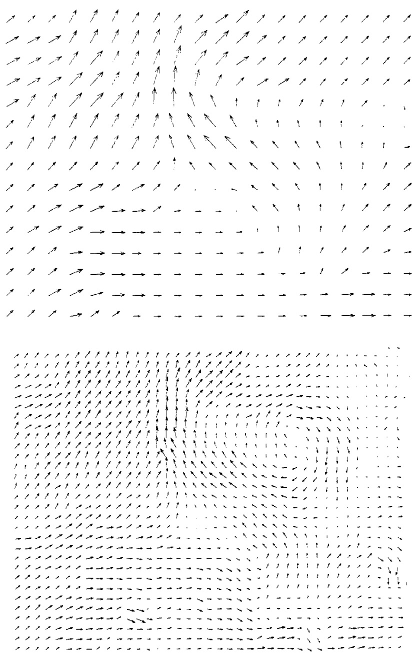

Figure 2: Turbulent velocity field in an adverse pressure gradient boundary layer. The upper picture shows a first estimate of the velocity field. This estimate is then used to obtain successive refinements so that more detailed structures can be resolved.

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 four 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. The project finished 1998 with an international conference at KTH Nov. 12-13, 1998.

The project financing expired June 30, 1997 but due to savings of funds it continued ti the end of 1998.

SToMP and CUPS have 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).

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.
Activities: 1. Göran Karlsson participated in the initial and budgetary meeting at University of Craiova February 20 - 26, 1998.2. Göran Karlsson visited University of Craiova June 27 - July 2, 1998 for a Short Intensive Course (SIC) June 30 and July 1 with the title:How to train trainers to design distance education using FirstClass and Internet. The course also included information about KTH and distance education at KTH.3. Göran Karlsson participated at the evaluation meeting at Eindhoven, The Netherlands, November 21 - 24, 1998.4. Staff mobility from Romania: June 18 - August 14, 1998: Liana Stanescu, Craiova and Laurentiu Tecsa, Petrosani (within the CECEN project); June 18 - August 19, 1998: Dan Ovidiu Andrei, Craiova and George Vlaescu, Craiova (within the INCOT project). Together they visited FCSweden (former GruppvaruExperterna) and Uppsala university June 22 - 26, NOEMA-CMI and Swedish Telepedagogics Knowledge Center summer camp in Haukassari outside Savonlinna/Nyslott in Finland June 27 - August 14. Andrei and Vlaescu visited KTH main campus and KTH-Haninge August 17 - 19.5. Staff mobility from Romania: October 2 - 31, 1998: Dan Selisteanu and Catalin-Cosmin Ionete. They had there main base during their visit at the Department of Signals, Sensors and Systems, Division of Automatic Control (prof. Bo Wahlberg), KTH. They also participated in some activities at the Department of Mechanics, KTH and visited the Continuing Education Programme at KTH.

Distance Education and Flexible Learning

Researcher: Göran Karlsson, Richard Hsieh

Sponsors: The Distance Consortium
Development of a national distance course for distance teachers. Period of development was Jan. 10 - Sept. 15, 1998 followed by the 5 credit point course starting on Oct. 19, 1998 and continuing spring 1999. Cooperating universities: KTH, University of Lund, University of Linköing , University of Uppsala, University of Umeá, University of Växjö.

Distance Teacher Education and PBL

Researcher: Göran Karlsson

Sponsors: Fees from participants' organisations

This 5 point credit course was originally developed through private investments outside KTH and from1998 integrated into KTH continuing education scheme; it is given in cooperation with University of Karlstad and FCSweden AB, Uppsala.

7 Research activities

7.1 Doctoral theses defended 1998

Per Elofsson

Thesis title: Experiments on oblique transition in wall bounded shear flows.

Date: May 28, 1998
Faculty opponent: Prof. Jacob Cohen, Technion, Haifa
Evaluation Committee: Prof Håkan Gustavsson, LuTH, Dr Rolf Karlsson, Vattenfall Utveckling AB, Prof. Leonhard Kleiser, ETH, Zürich,.
Main Advisor: Prof. Henrik Alfredsson

Per has started on a position at Volvo.

Stellan Berlin

Thesis title: Oblique waves in boundary layer transition.

Date: May 29, 1998
Faculty opponent: Prof. Leonhard Kleiser, ETH, Zurich, Switzerland
Evaluation Committee: Prof. Jacob Cohen, Technion, Haifa, Israel, Prof Håkan Gustavsson, LuTH., Dr. Mats Ramnefors, Volvo Data
Main Advisor: Prof. Dan Henningson

Stellan Berlin has started a position at Parallel Systems.

Mats H. Fredriksson

Thesis title: Topics in Impacting Systems

Date: December 11, 1998
Faculty opponent: Prof. Professor Hans True, Lingby Denmark
Evaluation Committee: Prof. Peter Gudmundson KTH Solid Mechanics, Prof. Håkan Eliasson KTH Mathematics, Prof. Anders Boström Chalmers Mechanics Department,
Main Advisor: Prof. Martin Lesser *Co Advisor:* Dr. Arne Nordmark

Mats will be starting work at a consulting firm in Stockholm in May 1999

Petra Wikström

*Thesis title:*Measurement, Direct Numerical Simulation and Modelling of Passive Scalar Transport in Turbulent Flows

Date: December 17, 1998
Faculty opponent: Prof. Hiroshi Kawamura, Science University of Tokyo, Japan
Evaluation Committee: Dr Nathalie Duquesne, Aeronautics, KTH, Prof. Lennart Löfdahl, Dept of

Thermo and Fluid Mechanics, Chalmers, Dr Said Zahrai, ABB Corporate Research, Västerås.
Main advisor: Prof. Arne Johansson.

Robert Tönhardt

Thesis title: Convective Effects on Dendritic Solidification

Date: December 18, 1998
Faculty opponent: Prof. Christoph Beckermann, University of Iowa, USA
Evaluation Committee: Dr. Torbjörn Carlberg, Mitthögskolan, Dr. Hans Åkerstedt, LTU, Dr Anders Szepessy, KTH.
Main Advisor: Gustav Amberg

7.2 Licentiate theses presented 1998

Casper Hildings

Thesis title: Simulation of Laminar and Transitional Separation Bubbles.

Date: Jan 14, 1998
External examiner: Dr. Ulrich Rist, Stuttgart University, Germany
Main Advisor: Prof. Dan Henningson

Casper Hildings has started a position at Hi-Q Data AB.

Renaud Lavalley

Thesis title: Experimental and Numerical Investigation of Thermocapillary Instabilities

Date: January 30, 1998
External examiner: Dr Rikard Gebart, LTU.
Main Advisor: Dr Gustav Amberg

Renaud has begun employment at ABB industrial systems in Västerås.

Stefan Wallin

Thesis title: Explicit algebraic turbulence models for the Reynolds stress tensor and the passive scalar flux vector

Date: February, 2, 1998
External examiner: Dr Nathalie Duquesne, Aeronautics, KTH
Main Advisor: Prof. Arne Johansson

Stefan is continuing towards a doctoral degree.

Mikael Sima

Thesis title: CFD Analysis of Sugar Crystallization

Date: March, 2, 1998
External examiner: Dr Gustav Amberg, Mechanics, KTH & Prof. Åke Rasmusson, Kemiteknik, KTH
Main Advisor: Prof. Henrik Alfredsson
Assisting Advisor: Dr Anthony Burden

Mikael has started a position at Prosolvia.

Naoki Yoshida

Thesis title: Nonlinear wave phenomena in a magnetized plasma and in a relativistic gas

Date: May 27, 1998
External examiner: Dr Ingemar Bengtsson, Stockholm Univ.
Main Advisor: Dr Lars Söderholm

Naoki has returned to Japan.

7.3 Conferences

The Second ERCOFTAC summerschool on turbulence and transition modeling 1998

The summer school was held June 10–16, 1998 and started off by two days of tutorials on turbulence modelling and stability and transition theory, similar to what was done in the first summer school (in 1995). During the next three days lectures on advanced topics were held. Approximately 70 people attended the summer school, which also included lab tours, a dinner at Värdshuset, KTH, and a boat trip to Sandhamn. The lecturers and the titles of their topics, in the order they appeared, were:

- Prof. Henrik Alfredsson, *Basic Stability*
- Adj. Prof. Dan Henningson, *Basic Stability*
- Prof. Arne Johansson, *Basic Turbulence Modelling*
- Dr Ardeshir Hanifi, FFA *Advanced Stability*
- Dr Anthony Burden, *Basic Combustion*
- Prof. Arne Johansson, *Advanced Turbulence Modelling*
- Prof. Uwe Dallmann, DLR, Göttingen, *Transition Prediction*
- Prof. Olivier, Metais, IMG, Grenoble, *LES of incompressible and compressible turbulence*
- Dr. Daniel Arnal, ONERA/CERT Toulouse, *Industrial transition pprediction*
- Prof. Sanjiva Lele, Stanford, *DNS of incompressible and compressible turbulence*

- Prof. Rainer Friedrich, TU München, *Compressible Turbulence modelling.*
- Prof. James Riley, Univ. of Washington, Seattle, *Combustion Modelling*

7.4 Publications 1997

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

1. Andersson, P., Berggren, M. and Henningson, D.S. 1999 Optimal Disturbances and Bypass Transition in Boundary Layers. To appear *Phys. Fluids.*

2. Andersson, P., Henningson, D.S. and Hanifi, A. 1998 On a stabilization procedure of the parabolic stability equations. *J. Eng. Math.* **33**, 311–332.

3. Bakchinov, A.A., Westin, K.J.A., Kozlov, V.V. & Alfredsson, P.H. 1998 Experiments on localized disturbances in a flat plate boundary layer. Part 2. Interaction between localized disturbances and TS-waves. *Eur. J. Mech./Fluids* **17**, 847–873.

4. Bech, K.H., Henningson, D.S. and Henkes, R.A.W.M. 1998 Linear and non-linear development of localized disturbances in zero and adverse pressure gradient boundary layers. *Phys. Fluids.* **10**, 1405–1418.

5. Berlin, S., Wiegel, M. and Henningson, D.S. 1998 Numerical and Experimental Investigations of Oblique Boundary Layer Transition. To appear *J. Fluid Mech.*

6. Dettmann, C.P. & Dahlqvist, P. 1998 Computing the diffusion coefficients for intermittent maps - Resummation of stability ordered cycle expansions , *Phys. Rev.* **E57** , 5303–5310.

7. Dahlqvist, P. & Vattay, G. 1998 Periodic orbit quantization of the Sinai billiard in the small scatterer limit, *J. Phys.* **A31**, 6345

8. Dankowicz, H., Coller, B.D. 1998 Evolving Control Strategies for Suppressing Heteroclinic Bursting, to appear in Dynamics and Control.

9. Dankowicz, H. 1998 On the Modeling of Dynamic Friction Phenomena, to appear in ZAMM.

10. Dankowicz, H., Nordmark A.B. 1998 Discontinuities in Friction Modeling, to appear.

11. Elofsson, P.A. & Alfredsson, P.H. 1998 An experimental study of oblique transition in plane Poiseuille flow. *J. Fluid Mech* **358**, 177–202.

12. Elofsson, P.A., Kawakami, M. & Alfredsson, P.H. 1998 Experiments on the stability of streamwise streaks in plane Poiseuille flow. Phys. Fluids (accepted).

13. Enflo, B.O. 1998 On the connection between the asymptotic waveform and the fading tail of an initial N-wave in nonlinear acoustics. *Acustica-Acta Acustica* **84**, 401–413.

14. Eriksson, J.E., Karlsson, R.I., & Persson, J. 1998: An experimental study of a two-dimensional plane turbulent wall jet. *Exp. Fluids* **25**, 50–60.

15. Essén, H. 1998 The Interior Schwarzschild Problem and its Integration. *Int. J. of Theor. Phys.* **37**, 875–889.

16. Essén, H. 1998 The field outside a spherical 2^l-pole distribution is a pure 2^l-pole field. *Am. J. Phys.* **66**, 163–163.

17. Fukagata, K., Zahrai, S. & Bark, F.H. 1998 Force balance in a turbulent particulate channel flow. *Int. J. Multiphase Flow,* **24**, 867-887.

18. Guillard, F., Fritzon, R. , Revstedt, J., Trägårdh, C., Alden, M. & Fuchs, L. 1998 Mixing in a confined turbulent impinging jet using Planar Laser Induced Fluorescence. *Experiments in Fluids,* **25**, 143–150.

19. Hanifi, A. and Henningson, D.S. 1998 The Compressible Inviscid Algebraic Instability for Streamwise Independent Disturbances. *Phys. Fluids.* **10**, 1784–1786.

20. Högberg, M. and Henningson, D.S. 1998 Secondary instability of cross-flow vortices in Falkner-Skan-Cooke boundary layers. *J. Fluid Mech.* **368**, 339–357.

21. Johansson, B. Apazidis., N., Lesser, M.B. 1998 On shock waves in a confined reflector. To appear in **Wear**

22. Kharkats, Yu.I., Bark, F.H. & Wedin, R 1998 On the theoretical aspects of thermal effectes in electrochemical cells. *J. Electroanal. Chem.,* **450**, 37-45.

23. Lindborg, E. Can the atmospheric kinetic energy spectrum be explained by two-dimensional turbulence? *J. Fluid Mech.*, Accepted

24. Lindborg, E. Correction to the four-fifths law due to variations of the dissipation *Phys. Fluids*, Accepted

25. Matsubara, M. & Alfredsson, P.H. 1998 Secondary instability in rotating channel flow. it J. Fluid Mech., **368**, 27–50.

26. Nyberg, C. 1998, Spectral analysis of a two frequency driven resonance in a closed tube. *Acoustical Physics* **6**, to appear.

27. Olivas, P., Zahrai, S. & Bark, F.H. 1998 On unsteady electrochemical coating of a cylinder at moderately large Reynolds number. *J. Appl. Electrochem* **27**, 1369-1379.

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

29. Reddy, S., Schmid, P.J., Baggett, J.S. and Henningson, D.S. 1998 On stability of streamwise streaks and transition thresholds in plane channel flows. *J. Fluid Mech.*, **365**, 269–303.

30. Sjögren, T.I.Å & Johansson, A.V. 1998 Measurement and modelling of homogeneous axisymmetric turbulence. *J. Fluid Mech.* **374**,59–90.

31. Söderberg, L.D. & Alfredsson, P.H. 1998 Experimental and theoretical stability investigations of plane liquid jets. *Eur. J. Mech./Fluids* **17**, 689–737.

32. Söderholm, L.H..Å 1998 13 Moments Equations Based on First-Order Chapman-Enskog Solution. *Transport Theory and Statistical Physics* **27**, 681-90.denna nr 1

33. Thylwe, K.-E. 1998 Higher-order narrow-tube quantization of quasi-energies. *J. Phys. A: Math. Gen.* **31** 2253-2268.

34. Thylwe, K.-E. & Korsch , H. -J. 1998 The 'Ermakov-Lewis' invariants for coupled parametric oscillators. *J. Phys. A: Math. Gen.* **31** L279-285.

35. Tönhardt, R. and Amberg, G. 1998 Phasefield Simulation of Dendritic Growth in a Shear Flow, *J. Crystal Growth*, **194**, 406–425.

36. Westin, K.J.A., Bakchinov, A.A., Kozlov, V.V. & Alfredsson, P.H. 1998 Experiments on localized disturbances in a flat plate boundary layer. Part 1. The receptivity and evolution of a localized free stream disturbance. *Eur. J. Mech./Fluids* **17**, 823–846.

37. Widlund, O., Zahrai, S. & Bark, F.H. 1998 Development of a Reynolds stress closure for modeling of homogeneous MHD turbulence. *Phys. Fluids,* **10:8**, 1987–1996.

38. Wikström, P.M., Hallbäck, M. & Johansson, A.V. 1998 Measurements and heat-flux transport modelling in a heated cylinder wake. *Heat and Fluid Flow.*, **19**, 556–562.

39. Yoshida, N., Nishinari, K., Satsuma, J., & Abe, K. 1998 Dromion can be remote-controlled. *J. Phys. A: Math. Gen.* **31**, 3325-36.

40. Zahrai, S., Bark, F.H. & Martinez, D.M. 1998 A Numerical Study of Cake Formation in 2-D Cross Flow Filtration. *J. Pulp and Paper Sci,* **24:9**, 281–285.

7.4.2 Published (and accepted) papers in conference proceedings

41. Carlsson, R., Karlsson, G. & Olsen, B. Distance Course for Training Trainers in the Use of Flexible Learning and PBL. In **Computer Aided Learning and Instruction in Science and Engineering**, pp. 205-209 *Proc. CALISCE'98, 4th International Conference,* Göteborg June 15 -19, 1998, ed. C. Alvegård, ISBN 91 7197 6833.

42. Enflo, B.O., Gurbatov, S.N. & Pasmanik, G.V. 1998 The decay of pulses with complex structure according Burgers' equation. In **Scientific/Technical Report No. 1998 - 04, Department of Physics, University of Bergen**, pp 35–36. *Proceedings of the 21th Scandinavian Symposium on Physical Acoustics,* Ustaoset Højfjellshotell 1-4 February 1998, ed. H. Hobæk.

43. Enflo, B. & Pavlov, I. 1998 Diffraction of sound against barriers with simple edge profiles. In **NAM 98**, pp 97–99. *Proceedings of the Nordic Acoustic Meeting,* Stockholm 7-9 September 1998, ed. Ulrica Kernen, Dep. of Building Technology, KTH.

44. Fukagata, K., Zahrai, S. & Bark, F.H. 1998 Fluid stress balance in a turbulent particulate channel flow. In *Proc. 3rd Int. Conf. on Multiphase Flow,* Lyon, France, 8-12 June (CD-ROM).

45. Lind, M., Lior, N., Alavyoon, F. & Bark, F.H. 1998 Flow effects and modeling in gas-cooled quenching. To appear in *Proc. 11th Int. Heat Transfer Conf.,*, Kyongju, Korea, Aug. 23-25.

46. Lindblad, I.A.A., Wallin, S., Johansson, A.V., Friedrich, R., Lechner, R., Krogmann, P., Schülein, E., Courty, J.-C., Ravachol, M. & Giordano, D. A prediction method for high speed turbulent separated flows with experimental verification. AIAA-98-2547, 29th AIAA Fluid Dynamics Conference, June 1998, Albuquerque.

47. Ljungkrona, L. & Klingmann, B. 1998 Cooling performance of the nozzle extension of the Ariane 5 core stage engine. *AIAA Joint Propulsion Conference and Exhibit,* Clevland, USA, 1998.

48. Matsubara, M., Alfredsson, P.H. & Westin, K.J.A. 1998 Boundary layer transition at high levels of free stream turbulence. Paper no 98-GT-248 ASME. International Gas Turbine & Aeroengine Congress & Exhibition, Stockholm, June 2-5, 1998.

49. Olsson, P.J. & Fuchs, L. 1998 The interaction of spherical particle in a fluid flow governed by the Navier-Stokes equations. Proceedings of 4th ECCOMAS Computational Fluid Dynamics Conference, Eds. Papailiou, Tsahalis, Periaux, Hirsch and Pandolfi, pp. 180–185.

50. Pavlov, I. & Enflo, B. 1998 Diffraction of sound against barriers with simple edge profiles. In **Scientific/Technical Report No. 1998 - 04, Department of Physics, University of Bergen**, p. 13. *Proceedings of the 21th Scandinavian Symposium on Physical Acoustics,* Ustaoset Høyfjellshotell 1-4 February 1998, ed. H. Hobæk.

51. Revstedt, J., Gullbrand, J., Guillard, F., Fuchs, L. & Trägårdh, C. 1998 Large Eddy Simulation of Mixing in an Impinging Jet. Proceedings of 4th ECCOMAS Computational Fluid Dynamics Conference.

52. Sandqvist, H. 1998 Shockwaves in a dispersive medium. In **Scientific/Technical Report No. 1998 - 04, Department of Physics, University of Bergen**, pp 41–42. *Proceedings of the 21th Scandinavian Symposium on Physical Acoustics,* Ustaoset Højfjellshotell 1-4 February 1998, ed. H. Hobæk.

53. Thuvander, A., Melander, A., Lind, M., Lior,N. & Bark, F.H. 1998 Prediction of heat transfer coefficients and examination of their effects on distrotion of tubes quenched by gas cooling. To appear in *Proc. 11th Cong.of the Int. Fed. for Heat Treatment and Surface Eng,*, Firenze, Italia, Oct. 19-21.

54. Thuvander, A., Melander, A., Lind, M., Lior, N. & Bark, F.H. 1998 Prediction of convective heat transfer coefficients and examination of their effects on distortion and mechanical properties of cylindrical bodies quenched by gas cooling. To appear in *Proc. 1999 ASME/JSME Thermal Eng. Joint Conf.*, San Diego, CA, March 19-23.

55. Tillmark, N. & Alfredsson, P.H. 1998 Large scale structures in turbulent plane Couette flow. In **Advances in Turbulence VII**, pp 59–62. *Proc. the Seventh European Turbulence Conference,* Saint-Jean Cap Ferrat, July 1998, ed. U. Frisch, Kluwer.

56. Widlund, O., Zahrai, S. & Bark, F.H. 1998 On MHD turbulence models for simulation of magnetic brakes in continuous steel casting processes. Transfer Phenomena in Magnetohydrodynamic and Electroconducting Flows. Alemany, A., Marty, P. & Thibault J.P. (Eds.), Kluwer Academic Publishers.

57. Wikström, P.M. & Johansson, A.V. 1998 DNS and scalar-flux transport modelling in a turbulent channel flow. In *proc. Turbulent Heat Transfer II,* May 31 - June 5, Manchester 1998.

58. Wikström, P.M., Wallin, S. & Johansson, A.V. 1998 Explicit algebraic modelling of passive scalar flux. In **Advances in Turbulence VII**, pp 281–284. *Proc. the Seventh European Turbulence Conference,* Saint-Jean Cap Ferrat, July 1998, ed. U. Frisch, Kluwer.

59. Winkler, C., Amberg, G., Inoue, H, and Koseki, T. 1998 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, 1998, Book 695.

7.4.3 Technical reports and papers submitted (accepted or in review process)

60. Amberg, G., Tönhardt, R, and Winkler, C. 1998 'Finite Element simulations using symbolic computing', *Mathematics and Computers in Simulation*, submitted.

61. Berlin, S. 1998 Oblique waves in boundary layer transition. *Doctoral thesis, Mechanics Dept., KTH.* TRITA-MEK Technical Report 1998:7.

62. Berlin, S., Kim, J. and Henningson, D. S. 1998 Control of oblique transition by flow oscillations. Technical Report *TRITA-MEK 1998:6*, Royal Institute of Technology, Stockholm.

63. Cederholm, A.& Lundell, F. A study of the velocity and temperature boundary layers over a heated rotating disk. Master's thesis 1998:10.

64. Dahlqvist, P. From chaotic to disordered systems - a periodic orbit approach, *J. Phys.* **A**, to appear.

65. Dahlqvist, P. Error of semiclassical errors in the semiclassical limit - An asymptotic analysis of the Sinai billiard, chao-dyn/9812017.

66. Elofsson, P. 1998 Experiments on oblique transition in wall bounded shear flows. *Doctoral thesis, Mechanics Dept., KTH.* TRITA-MEK Technical Report 1998:5.

67. Fredriksson, M. 1998 Topics in impacting system dynamics. *Doctoral thesis, Mechanics Dept., KTH.* TRITA-MEK Technical Report 1998:10.

68. Fukagata, K., Zahrai, S. & Bark, F.H. 1998 Large Eddy Simulation of Paticle Motion in a Turbulent Channel Flow. Submitted to Fluid Dyn. Res.

69. Gurniki, F., Fukagata, K., Zahrai, S. & Bark, F.H. 1998 Mass transfer of a binary electrochemical electrolyte in the near-wall region of a turbulent flow. Submitted to J. Appl. Electrochem.

70. Henningson, D. S. and Berggren, M. 1998 TVR report on future areas of research: Optimal Design and Control of Fluid Flows. Report *FFAP-250*, Aeronautical Research Institute of Sweden, Bromma.

71. Dankowicz, H., On the Successive Constraints Approach to Multibody Mechanisms, in submission.

72. Dankowicz, H., Nordmark, A.B., On the Origin and Bifurcations of Stick-slip Oscillations, in submission.

73. Dankowicz, H., Adolfsson, J., Nordmark, A.B., Existence of Stable 3D-Gait in Passive Bipedal Mechanisms, in submission.

74. Dankowicz, H., Mechanics Problems and their Solutions, in submission.

75. Häggmark, C.P. Bakchinov, A.A. & Alfredsson, P.H. Measurements with a flow direction boundary-layer probe in a two-dimensional laminar separation bubble. *Exp. Fluids* (submitted).

76. Häggmark, C.P. Bakchinov, A.A. & Alfredsson, P.H. Experiments on a two-dimensional laminar separation bubble. *Phil. Trans. R. Soc. Lond.* A (submitted)

77. Lavalley, R., Amberg, G. and Alfredsson, P.H. 1998 Experimental and numerical investigation of nonlinear thermocapillary oscillations, *European Journal of mechanics B*, submitted.

78. Levenstam, M., Amberg, G., and Winkler, C. 1998 Instabilities of thermocapillary convection in a half-zone at intermediate Prandtl numbers, *Physics of Fluids*, submitted.

79. Nielsen, S.F., Dahlqvist, P & Cvitanović, P. 1998 Periodic orbit sumrules: Accelerating cycle expansions, preprint, chao-dyn/9901001, submitted to *J. Phys.* **A**.

80. Sima, M. 1998 CFD analysis of sugar crystallization. *Licentiate thesis, Mechanics Dept., KTH.* TRITA-MEK Technical Report 1998:2.

81. Söderholm, L.H. & Yoshida, N.,1998 Moment equations based on first order Chapman-Enskog solution - relativistic gas - in Trita-Mek Technical Report 1998:8.

82. Söderholm, L.H. 1998 Heat Transfer to a Small Body in Shearing Gas Flow. Preprint.

83. Söderholm, L.H. 1998 A Generalized Fermi Derivative and Dissipative Gas Dynamics Equations. Preprint. Submitted to Classical and Quantum Gravity.

84. Talamelli, A., Westin, K.J.A. & Alfredsson, P.H. 1998 An experimental investigation of the response of hot-wire X-probes in shear flows. *Exp. Fluids* (submitted).

85. Thor, A.J. 1998 SI Guide, ISO, Genève,1998 (ISBN 92-67-10279-6).

86. Tönhardt, R 1998 Convective effects on Dendritic solidification. *Doctoral thesis, Mechanics Dept., KTH.* TRITA-MEK Technical Report 1998:14.

87. Tönhardt, R, and Amberg, G. 1998 Dendritic growth of randomly oriented nuclei in a shear flow, *J. Crystal Growth*, submitted.

88. Wallin, S. 1998 Explicit algebraic turbulence models for the Reynolds stress tensor and the passive scalar flux vector. *Licentiate thesis, Mechanics Dept., KTH.* TRITA-MEK Technical Report 1998:1.

89. Wikström, P.M. 1998 Measurement, direct numerical simulation and modelling of passive scalar transport in turbulent flows. *Doctoral thesis, Mechanics Dept., KTH.* TRITA-MEK Technical Report 1998:11.

90. Yoshida, N. 1998 On nonlinear wave phenomena in a magnitized plasma and in a relativistic gas. Licentiate Thesis. *Licentiate thesis, Mechanics Dept., KTH.* Trita-Mek Technical Report 1998:8.

7.5 Seminars

Two series of regular seminars have been given during 1998, 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 29 Stellan Berlin:
Oblique boundary layer transition

February 4 Arne Nordmark:
Systems with a Preferred Spin Direction

February 5 Per Olsson:
Influence of small spherical particles on a flow governed by Navier-Stokes equation

February 12 Robert Tönhardt :
Dendrite growth in shear layers

February 18 Lars Bengtson, Knowledge Works Nordic University:
Working Model, a graphic interface for computational programs

February 19 Peter Yakubenko, Department of Hydralic Engineering, KTH :
Over-reflection and shear instability in shallow water

February 26 Krister Alvelius :
Random Forcing of three-dimensional turbulence

February 27 Prof. Alf Sjölander, Chalmers, Gothenburg, Alfvén Laboratory, KTH:
Dynamics of liquids from microscopic point of view

March 4 Naoki Yoshida, Dept. of Mech., KTH:
The dromion : a localized structure of an ion wave in a magnetized plasma

March 5 Ruben Wedin :
Diffusion of small bubbles in a vertical channel

March 12 Jonas Gustavsson :
PIV measurements of turbulent flow separation

March 18 Professor Bernard Roth, Mechanical Engineering Dept.; Stanford University, USA :
Elimination based methods for solving the non-linear equations of mechanism and robot kinematics

March 19 Jonas Gunnarsson :
Experimental investigation of rotating duct flow

April 1 Per Dahlqvist, Dept. of Mech., KTH:
¿From Chaotic to Disordered Systems

April 15 Docent Pawel Artymowicz, Stockholm Observatory:
Fluid dynamics of binary star and planet formation

April 29 Henrik Sandqvist:
Shock wave in a dispersive medium

May 13 Docent Hans Rickman, Uppsala Astronomical Observatory:
Modeling gas and dust outflow from cometary nuclei

May 27 Naoki Yoshida :
Licentiate seminar. Nonlinear wave phenomena in a magnetized plasma and in a relativistic gas.
Opponent: Docent Ingemar Bengtsson, Department of Physics, University of Stockholm

June 3 Ivan Pavlov:
Diffraction of Sound Against Barriers with Simple Edge Profiles

August 6 Professor Yoshio Sone, Kyoto University:
Ghost effect of a rarefied gas in continuum gas dynamics

September 24 Rebecka Lingwood, Department of Engineering, University of Cambridge:
Flow over elastic walls

October 1 Markus Högberg :
Control of flow instabilities

October 8 Jerome Ferrari :
Simulation of a gas quenching chamber

October 14 Dr Carl Dettman, Niels Bohr Institute, Copenhagen:
Chaotic dynamics with weak noise - perturbative field theory without Feynman diagrams

October 15 Martin Skote :
Simulation of turbulent boundary layers under adverse pressure gradients

October 21 Professor Oleg V. Rudenko, Moscow State University:
Shear wave elasticity imaging (SWEI) - a new application of nonlinear acoustics in medicine

October 22 Björn Lindgren :
Design of the new wind tunnel :
Followed by OPENING CEREMONY!

October 29 Lars Söderholm :
Heat transport to small particles in shearing gas flow

November 4 Mats Fredriksson, Dept Mechanics and Dan Borglund, Dept Aeronautics:
Experiments on the onset of impacting motion using a pipe conveying fluid

November 12 Michael Vynnycky :
Prandtl-Batchelor flow

November 19 Wei Shyy, Chairman of the Aerospace, Mechanics and Engineering Science Department, University of Florida :
Computational Fluid and Fluid-Structure Dynamics with Moving Boundaries

November 25 Lars Langemyr, Peo Persson, Comsol, Stockholm:
FEMLAB for Mechanics

November 25 Henrik Alfredsson :
Hot-wire measurements near solid walls

December 3 Mehran Parsheh :
Turbulence measurements at a plain contraction

December 9 Prof. Sergey N. Gurbatov, Department of Radiophysics, Nizhny Novgorod State University, Russia:
nbsp;Nonlinear evolution of regular and random acoustic pulses

December 10 Professor Hans True Institut for Matematisk Modellering Danmarks Tekniske Universitet:
Icke-linjär Järnvägsfordonsdynamik, Bifurkationer och Kaos

December 10 Martin Ingelman-Sundberg :
The mechanics in the incompressibility assumption of the wing theory pioneer, F.W.Lanchester, became overlooked by his followers. It has led to a lie about Bernoulli, which has misled all the world's pilots about aerodynamics.

December 17 Dr. Karol Zyczkowski, Smoluchowski Institute of Physics, Jagiellonian University, Cracow:
Monge Distance between Quantum States

7.6 Presentations by staff during 1998

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 *Streak growth, instability and breakdown.* Invited talk at Turbulence Modelling and the Theory of Hydrodynamic Instabilities, COST-ERCOFTAC Workshop on Instabilities and Turbulent Flows, Observatoire de Haute Provence, France, 6-9 July 1998.

G. Amberg *Numerical Simulation by Symbolic Computation.* Presentation at 1998 Nordic Computational Differential Equation Circus, January 9-10 1998, CTH, Göteborg.

G. Amberg *Simulation of solidification and fluid flow in materials science using a general FEM problem solving environment* Invited seminar at Chalmers University of technology, Göteborg, March 24 1998.

G. Amberg *Numerical Simulation by Symbolic Computation.* Presentation at 1998 IMACS Conference on Applications of Computer Algebra, August 9-11, 1998, Prague, Czech Republic.

G. Amberg *Ytspänningsdriven strömning* Presented at 'Workshop inom sintring', organized by the Brinell Centre, KTH, August 18 1998.

G. Amberg *Numerical Modelling of Materials Processes* Invited seminar at Nippon Steel research laboratories, Futtsu, Japan, 13 Oct 1998.

A.A. Bakchinov, M.M. Katasonov, P.H. Alfredsson & V.V. Kozlov *Control of boundary layer transition at high FST by localized suction.* Presented at IUTAM-Symposium on Mechanics of Passive and Active Flow Control, Sept. 7-11, Göttingen.

P . Dahlqvist, *What billiards are good for*, Colloquium, Matematikcentrum, Göteborg,14 Dec 1998.

H. Dankowicz
On the Origin and Bifurcations of Stick-Slip Oscillations presented at:

- Univ. of Maryland at College Park, Institute for Physical Science and Technology, College Park, Maryland, USA
- Princeton University, Program for Applied and Computations Mathematics, Princeton, New Jersey, USA
- Brown University, Division of Applied Mathematics, Providence, Rhode Island, USA
- International Symposium on Impact and Friction in Structures and Mechanisms, Ottawa, Canada

Stable Three-Dimensional Gait in Two-Legged Mechanisms/ presented at:

- EUROMECH 375, Biology and Technology of Walking, Munich, Germany

- Massachusetts Institute of Technology,Leg Laboratory, Boston, Massachusetts, USA
- Boston University, Dept. of Mechanical Engineering, Boston, Massachusetts, USA
- Brown University, Dept. of Computer Science, Providence, Rhode Island, USA
- Yale University, Dept. of Mechanical Engineering, New Haven, Connecticut, USA

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

C.P. Häggmark, A.A. Bakchinov & P.H. Alfredsson *Experimental study of a transitional two-dimensional separation bubble.* EUROMECH 384 Colloquium on steady and unsteady separated flows, July 6-9, 1998, Manchester.

G. Karlsson *Distance Course for Training Trainers in the Use of Flexible Learning and PBL* Presentation at RUFIS'98, Universidad Regiomontana, Monterrey, Mexico 22-24 July, 1998.

G. Karlsson *Distance Course for Training Trainers in the Use of Flexible Learning and PBL* Presentation at LINKS'98, Stockholm 26-28 October, 1998.

G. Karlsson *Distance Course for Training Trainers in the Use of Flexible Learning and PBL* Presentation at FLIP'98, Stockholm 12-13 November, 1998.

R.I. Karlsson 1998. *Flow Control through Redesign.* Presentation given at the Abisko Workshop on Flow Control. Ed. H. Gustavsson, Luleå University of Technology.

R.I. Karlsson 1998. *Turbulence Troubleshooting: Case Studies in Industrial Design.* Invited presentation given at the Symposium Turbulence for the New Millenium, in celebration of the 20th Anniversary of the the Turbulence Research Laboratory, University at Buffalo.

R.I. Karlsson 1998. *Strömningsteknik i industrin - FoU och problemlösning.* Seminarium för forskarstuderande vid Iinstitutionen för Konstruktions- och Produktionsteknik, Linköpings Tekniska Högskola (september), samt vid Inst. för Kraft- och Värmeteknik, Lunds Tekniska Högskola (december).

(J. Gustavsson and) B. Muhammad-Klingmann *Turbulent flow separation - a PIV study.* Presented at the Eurmech 384 Colloquium on Steady and Unsteady Flows, Manchester, July 6-9, 1998

M. Lesser*Computer Algebra and Mechanics Whipstaff.* Presentation at Chalmers Dept. of Mechanics April 1998

E. Lindborg *Is the atmospheric kinetic energy spectrum due to two-dimensional turbulence?* Secon Monte-Verita Colloquium, Monte-Verita, Mars 1998

E. Lindborg *Is the atmospheric kinetic energy spectrum due to two-dimensional turbulence?* ETC 7, Nice, June 1998

F. Lundell & P.H. Alfredsson *Control of streak instabilities in boundary layer flows with application to free stream turbulence induced transition.* Workshop on Flow Control and Design. April 26-28, Abisko.

F. Lundell & P.H. Alfredsson *Control of streak instabilities in channel flow by localized suction.*

IUTAM Symposium on Mechanics of Passive and Active Flow Control, Sept. 7-11, DLR, Göttingen.

B. Lindgren *A new small wind-tunnel at KTH.* Workshop on Flow Control and Design. April 26-28, Abisko.

L. H. Söderholm, *Heat Transfer to a Small Body in Shearing Gas Flow.* Presentation at XXth International Conference on Statistical Physics, Paris, 20-24 July, 1998

L. H. Söderholm, *Heat Transfer to a Small Body in Shearing Gas Flow* 29 October 1998. Presentation in the series "fikaseminarier", Department of Mechanics, KTH.

C. Winkler *Numerical Modelling of Welding* Seminar at Nippon Steel Research Laboratories, Futtsu, Japan, 23 Jul 1998. C. Winkler *The Effect of Surfactant Redistribution on the Weld Pool Shape During GTA-Welding* Presentation at 1998 National Japanese Arc Commitee, 19 Nov 1998, Nihon Kokan Research Laboratories, Nagoya, Japan. C. Winkler *Two- and Three-Dimensional Analysis of Fluid and Heat Flow in a Weld Pool* Seminar at Nippon Steel Research Laboratories, Futtsu, Japan, 30 Nov 1998.

N. Yoshida & L. H. Söderholm, *Moment equations based on first order Chapman-Enskog solution - relativistic gas.* Presentation at 21st International Symposium on Rarefied Gas Dynamics 27-31 July Marseille, France

7.7 Visiting scientists

Prof. Oleg V. Rudenko, Department of Acoustics, Moscow State University, Moscow, Russia, 7 October - 20 November 1998.

Prof. Sergey N. Gurbatov, Department of Radiophysics, Nizhny Novgorod State University, Nizhny Novgorod, Russia, 18 November - 12 December 1998.

Dr. Roza Dumbraveanu, State University of Moldova, Chisinau, Moldova, Royal Swedish Academy of Sciences, from Oct. 1998.

Dr Carl P Dettmann, Niels Bohr Institute, Copenhagen, 2 weeks, October 1998.

Sune F. Nielsen, Niels Bohr Institute, Copenhagen, 6 months 1998.

Tadahisa Terao, Univ. of Tokyo, April 1998 – May 1999.

PhD-student Naoki Yoshida, University of Tokyo, Japan, April 1997-May. 1998 (13 months)

Prof. Peter Schmid, Applied Mathematics, University of Washington, Seattle. May-June, 1998 (6 weeks).

PhD-student Michael Katasonov, Institute of Theoretical and Applied Mechanics, Russian Academy of Sciences, Novosibirsk, Russia, Dec. 1998-Feb. 1999 (3 months)

Prof. Viktor Kozlov, Institute of Theoretical and Applied Mechanics, Russian Academy of Sciences, Novosibirsk, Russia, Jan. 1998 (4 weeks)

Dr. Rebecca Lingwood, Daprtment of Engineering, Cambridge University, Aug-Sept 1998 (6 weeks)

Prof. Alessandro Talamelli, Department of Aeronautics, University of Pisa, Aug-Sept 1998 (6 weeks)

PhD-student Gabriel Usera, Institute of Fluid Mechanics and Environmental Engineering Universidad de la Republica, Montevideo, Uruguay, Oct - Dec 1998 (3 months)

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

– Prof. Zbigniew Peradzynski, Institute of Fundamental Technological Research, Polish Academy of Sciences, Warsaw, Poland, 24-30 October 1998.
– Mr. Dimitris Mitsakis, Athens, Nov. 11-18, 1998.
– Prof. Y. Sone, Department of Aeronautical Engineering, Kyoto University, Kyoto, Japan, 1-6 August, 1998.
– Prof. K. Aoki, Department of Aeronautical Engineering, Kyoto University, Department of Aeronautical Engineering, Kyoto, Japan, 1-5 August, 1998.
– Prof. C. Beckermann, Dept of Mechanical Engineering, University of Iowa, Iowa City, USA
– Prof. HH. Fernholz, TU Berlin
– Dr. Carlo Casiola, Aeronautics Department, University of Rome, June 1998.
– Dr. Jonathan Healey, Department of Mathematics, University of Keele, England 2-4 Sept. 1998.
– Prof. M. Gad-el-Hak, University of Notre-Dame, USA 30/4-1/5.

7.8 Visits abroad by staff (>2 weeks)

Henrik Alfredsson visited Tohoku University Sendai two weeks in November 1998.

Christian Winkler spent the period July-December 1998 at Nippon Steel research laboratories, Futtsu, Japan.

8 Other activities

Henrik Alfredsson
- dean of Faculty of Engineering Physics
- chairman of Swedish National Committee for Mechanics
- reviewer for J. Fluid Mech., Phys. Fluids, Eur. J. Mech. B/Fluids
- opponent at Ph.D. dissertation in fluid mechanics at LTU, Luleå, Sept. 98

Gustav Amberg
- 25 % financing from KTH ('LUFT medel').
- Served in the working group for research issues of the school of technical physics
- Served on the evaluation committee at the dissertation of R. Nourgaliev, KTH.
- Secretary of the Swedish National Committee for Mechanics (SNM)
- Reviewer for J. Fluid Mech., Physics of Fluids., AIAA/ASME joint Conf.
- Visited Nippon Steel research laboratories 11-16 Oct 1998.

Nicholas Apazidis
- Referee for: Int. J. Multiphase Flow, Canadian Journal of Chemical Engineering
- Opponent at the PhD thesis: Flow and clogging mechanisms in porous media with applications to dams. Martinet, P., KTH 1998
- Advisor for Bo Johansson

Fritz Bark
- acted as director of the Faxén Laboratory, see separate report January - June
- acted on one PhD evaluation committee ('betygsnämnd') at KTK (MMT).
- sabbatical leave July - December
- member of the editorial board of ZAMP.
- directed and participated in the writing of the proposal "Fibres, Bubbles, and Particles in the Process Industry", A Proposal for a Graduate School and an Associated Strategic research Programme in Multiphase Flow for Chemistry and Process Technology, submitted to Stiftelsen för Strategisk Forskning. The proposal was approved.

Anthony Burden
- member of the University's Council for Equal Opportunities.
- member of the International Committee of the School of Engineering Physics.

Ian Cohen
- Coordinater for the AMIS project to produce materials for undergraduate mechanics on Internet
- Advisor to a similar British project SToMP producing materials for a CD-rom.

Anders Dahlkild
- reviewed manuscripts for Int. J. of Multiphase Flow

- member of Hannes Vomhoff's PhD examination committee at KTH on Dec 10
- acting director of the FaxénLaboratory, 'Kompetenscentrum Processteknisk Strömningsmekanik' at KTH, 980701-981231.
- acting professor at Dept. of Mechanics during sabattical of Fritz Bark 980701-981231.

Per Dahlqvist
- Three day visit at NORDITA, Copenhagen, November 1998.
- Member of "Censorkorpset for Fysik", Denmark.
- Reviewed manuscripts for J.Phys **A**.

Harry Dankowicz
- Reviewer for Dynamics and Stability of Systems
- Awarded Junior Individual Grant from the Foundation for Strategic Research
- Advisor for Petri Piiroinen

Bengt Enflo
- reviewer for Acustica - Acta Acustica
- Contractor of the EU-project INTAS-RFBR 95-0723, entitled "Two-phase turbulence in hydrodynamics, cosmology and nonlinear acoustics".
- Research visit with presentation of a seminar at Department of Mathematics, Kent State University, USA, 9-16 February 1998.

Hanno Essén
- 30 % financing from TFR resources (Projekt: Mechanics at small length scales).
- 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 Nordic ERCOFTAC Pilot Center
- member of ERCOFTAC Managing Board and Scientific Program Committee
- Chairman 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 at Rutgers Univ., N.J. June 1999.
- 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.
- reviewed manuscripts for J. Fluid Mech., Physics of Fluids, European Journal of Mechanics B/Fluids., Flow, Turbulence and Combustion, and for several conferences
- served on the FAKIR group at KTH.
- served on 'It-Rådet' KTH.

Göran Karlsson
- Member of Program and Coordination Committees for the conferences:
  CALISCE'98, Göteborg June 15 -19, 1998
  RUFIS'98, Monterrey, Mexico July 22 - 24, 1998
- Member of editorial board for European Journal of Engineering Education

Rolf Karlsson
- Member of the Managing Board, Scientific Program Committee and Industrial Advisory Committee of ERCOFTAC.
- Chairman of the board of "Faxén Laboratory".
- 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, Lisbon July 1998.
- Reviewer for Exp. Fluids and Journal of Fluids and Structures. Reviewer for 4th Int. Symp. on Engineering Turbulence Modelling and Measurements, May 24-26, 1999.
- Member of grade committee for two PhD dissertations. Faculty opponent at two PhD dissertations (Linköping and Lund).

Barbro Muhammad-Klingmann
- Referee for: European Journal of Mecahnics B. Fluids
- Opponent at the LicD thesis: A study of hypersonic afterbody flow fields
  Tor-Arne Grönland, KTH 1997
- External project: Litterature study on the heat transfer of dual-bell exhaust nozzles, for Volvo Aero Corp., Space Division, Trollhättan
- External project: Wind tunnel investigation of flow around ceiling elements of a car tunnel, for Vägverket, Region Stockholm
- External project: PIV-measurement on a 2D wind turbine blade model, in cooperation with FFA, Stockholm
- Advisor for Kristian Angele

Martin Lesser
- associate Editor of J. of Bifurcation and Chaos
- reviewer for Proc. Roy. Soc. of London, J. Bifurcation and Chaos,
- member of the Faculty of Engineering Physics Appointment Committee.
- Elected Member of the board of CISM, Udine Italy.
- served on the central faculty council committee for appointments.
- reviewer for Lecturer Position in Mechanics at Lund.
- reviewer for Professorial Position at Chalmers
- reviewer for docent position at Lund.
- reviewer for docent position at Luleå

Erik Lindborg
• Referee for J. Fluid Mech., Phys. Fluids and "Flow, Turbulence and Combustion"

Arne Nordmark
• reviewer for Int. J. of Bifurcation and Chaos., Proc. of the Royal Soc. of London

Christer Nyberg
• wrote course material for the basic and continuation courses.

Lars Söderholm
• was the referee (examinator) for three master thesis students
• Arranged the seminar series of theoretical and applied mechanics.
• Reviewer for Earth, Moon and Planets and for Classical and Quantum Gravity
• Member of grading committee of theoretical physics dissertation at Stockholm University June 1998.

Anders J Thor
• Secretary of ISO/TC 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.
• Chairman of SACO at KTH.

Nils Tillmark
• reviewed manuscripts for Phys. Fluids , Exp. Fluids and J. Fluids Eng.

9 The Faxén Laboratory

A short description of the Faxén Laboratory is given below for the period July 1997 – June 1998. The text in this 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: Göran Lindberg, 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 annular 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

I:6 Hydrodynamics of solid polymer fuel cells/ MISTRA
- Researcher: Erik Birgersson - advisor: Göran Lindberg, Michael Vynnycky

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

III:3 Fibre suspensions in contractions Analysis of the orientation of fibres in a headbox
- Researcher: Mats Ullmar - advisor: Bo Norman

III:4 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) Daniel Söderberg and Mats Ullmar, 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 1998 reached 15 MSEK.

The total cash (in MSEK) contributions for 1998 from the three major parties amount to:

KTH	3.6
Industry	2.1
NUTEK	5.2
Σ	11

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: Erik Birgersson 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), Mehran Parsheh (M), Daniel Söderberg (M), Mats Ullmar (PM)

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 Strategic 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). The SSF-board decided to grant the proposal during at least 5 years with 6 Mkr for the year 1999 and 6-10 Mkr for the years 2000-2001.

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:

- 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
- Udine September 7-11 8th IUTAM International Summer School: Advanced Turbulent Flow Computations Participant from FaxénLab was Mehran Parsheh.
- London November 26, 1998: CFX-course at AEA-technology Participant from FaxénLab was Ruben Wedin

The year 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.
- February 4: Visit by Profs André Tess and Oleg Zikanov, TU Dresden
- April 27-28: FPIRC/FLA workshop in paper technology
- September 8-10: Extra course in scientific writing for graduate students (lectures by David G. Crighton and Bengt Lundberg).
- September 16-17: Annual Meeting of the FaxénLaboratoriet at Albany Nordiskafilt AB in Halmstad.