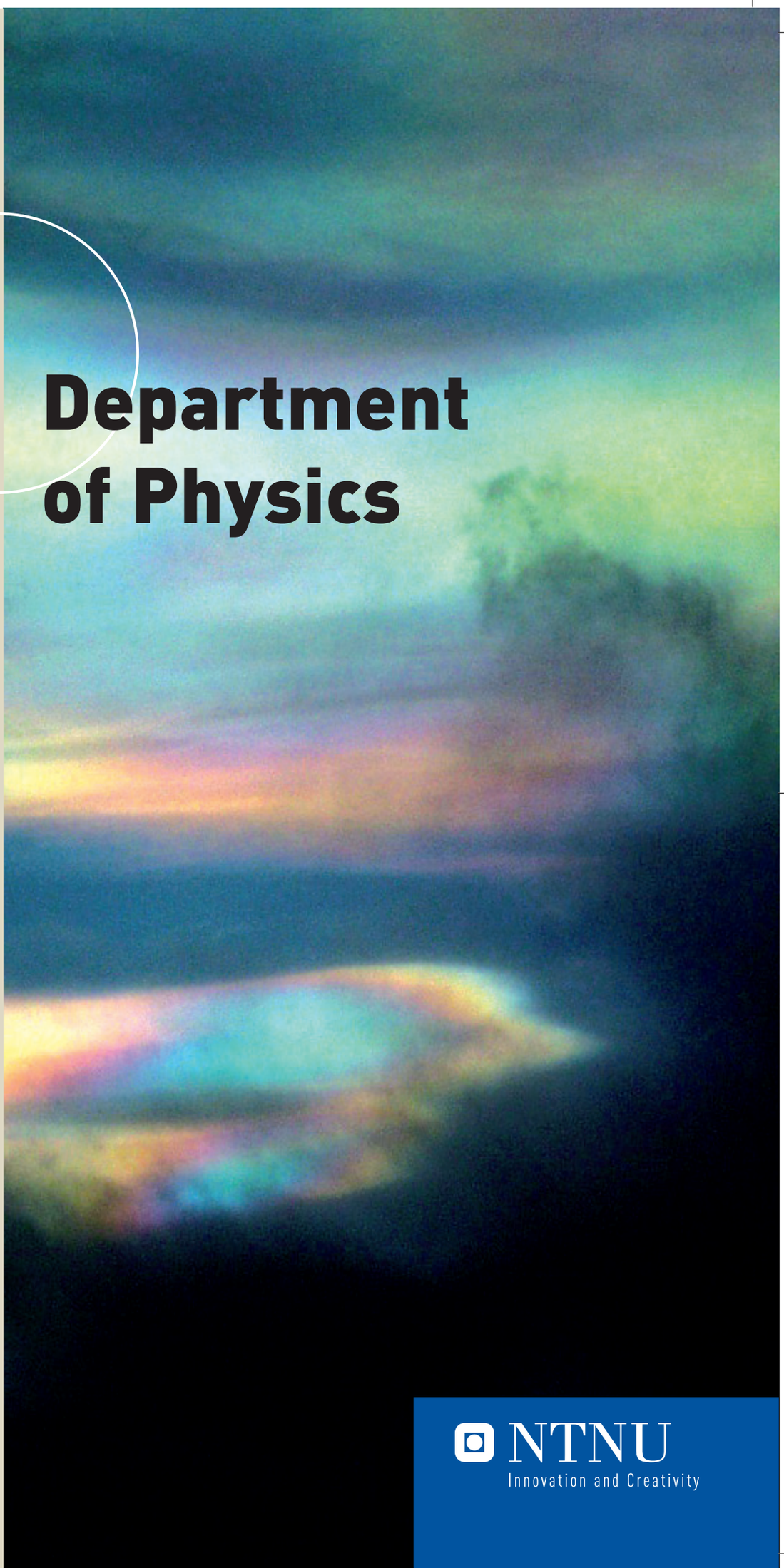
Annual Report 2005

Department of Physics



NTNU
Innovation and Creativity

GOVERNING BODY UNTIL JULY

Head of the Department:	Professor Anders Johnsson
Deputy Head of the Department:	Professor Alex Hansen
Head of Administration	Head Engineer Sylvi Vefsnmo

Departmental Board

Head of the Department:	Professor Anders Johnsson
Deputy Head of the Department:	Professor Alex Hansen

Elected members:

Representing the permanent scientific staff:	Professor Catharina Davies
	Professor Ola Hunderi
	Professor Berit Kjeldstad
	Professor Asle Sudbø
Representing the temporary scientific staff:	PhD-student Trude Støren
Representing the technical/administrative staff:	Executive Officer Margit Hagen
Representing the students of the department	Student Sigmund M. Hope
	Student Torgar Haugen
Appointed external member:	Managing Director Terje Eidesmo Electromagnetic Geoservice

GOVERNING BODY FROM AUGUST

Head of the Department:	Professor Bjørn Torger Stokke
Deputy Head of the Department:	Professor Kåre Olaussen
Head of Administration	Head Engineer Sylvi Vefsnmo

Departmental Council

Elected members:

Representing the permanent scientific staff:	Professor Randi Holmestad
	Professor Catharina Davies
	Professor Alex Hansen
	Professor Mikael Lindgren
Representing the temporary scientific staff:	Post doc Anh Kiet Nguyen
Representing the technical/administrative staff:	Head Engineer Oddbjørn Grandum
Representing the students of the department	Student Ole Martin Tranvåg Solås
Appointed external member:	Research Manager Jostein Mårdalen (chair) SINTEF Materials and Chemistry
	Professor Lisa Lorentzen, NTNU, Department of Mathematical Sciences

Cover page: Mother-of-pearl clouds
Polar stratospheric clouds, called “Mother-of-pearl” clouds, consist of ice particles of water and acid. They are formed in the stratosphere between 15-30 km above the ground at temperatures below -78 ºC. They catalyse the destruction of ozone.
Photo: Ole Johan Løkberg

DEPARTMENT OF PHYSICS, NTNU

www.phys.ntnu.no

CONTENTS

Edited by:

Sylvi Vefsnmo, Berit Kjeldstad, Emil J. Samuelsen and Arne Mikkelsen

The Annual report is also available on the internet address:

http://www.phys.ntnu.no/instdef/rapporter/aarsrapport/index-e.html

SYNOPSIS OF EVENTS IN 2005

The Department has high ambitions to provide excellent education to undergraduate and graduate students, to conduct research in several areas of basic and applied physics at a high international level, and to disseminate popularized information on topics related to physics.

Several teachers with long-lasting duties retired in 2005. The Department thanks them for all their efforts, long standing great contributions to our activities and wish them many successful years ahead. We were pleased to be able to welcome new staff in theoretical astroparticle physics, in condensed matter physics, and in bionanotechnology. Thus Jens Andersen, Michael Kachelriess, Erik Wahlström and Pawel Sikorski started their work at the Department in 2005.

Also the technical staff was partly renewed. We thank the colleagues who leave us and welcome Heimir Magnusson.

The Norwegian implementation of the European Bologna process in higher education, nationally known as the ”Quality Reform” continued throughout the year. Following partly restructuring of the teaching programmes in 2004, the Department focussed on even more intensive teaching and contact with the students during 2005.

The number of student credits at the Department increased. Simultaneously the number of teachers was reduced during the year. It will be difficult to further rationalize the courses offered. Statistics over the last five years is presented in the annual report.

In 2005, a total of 63 Master of Science in Applied Physics and Mathematics, and ten Master of Science in Physics, have been awarded. In addition, The Department teaches physics to more than 1200 students from other faculties. We thank all the students for their participation in our teaching efforts, contributing with enthusiasm and new ideas. We also hope they have acquired skill, knowledge and contacts that are necessary in their important jobs in society.

The research activities have been at a high level during the year. The Department of Physics is particularly proud of the fact that one of its staff members, professor Asle Sudbø, was awarded the Møbius prize for the year 2005. This is the most prestigious Norwegian research prize, awarded by the Research Council of Norway. Asle Sudbø was awarded this prize for his high-quality publications within theoretical condensed matter physics. Also the doctoral students within the research group have been awarded high ranking prizes during the year – mentioned below.

The Department of Physics maintains a key position in the building up of the new nanotechnology laboratory and the nanotechnology studies at NTNU. In addition to the recently hired staff member in bionano-technology, several active staff members in topics central to this initiative are involved. A new chair in the related field of physics of functional materials is being announced.

The Department staff continues to attract significant external funding for their projects. The total level of funding from external projects was about the same as in the year 2004.

A collaboration effort between NTNU and SINTEF resulted in the creation of a so-called GEMINI centre at the Department. The field of research in this centre is “solar cell materials”. Such centres will be particularly strong in combining basic research and applied efforts in specific priority areas.

The year 2005 was the official “World Year of Physics”. The Department had an active approach to this worldwide celebration of the anniversary of Einstein. The staff was heavily involved in public seminar series, school visits, conferences and other arrangements. In particular it is proper here to mention “The Physics Trail”. Twelve years old school children were invited to the Department to play and study a row of activities under guidance of students from the Department and their teachers. The successful arrange-ment comprised more than 1100 school children and attracted much interest and enthusiasm. The Department aims for a prolongation of this initiative and other ideas and events in the years to come.

The staff has been engaged in a number of external activities, in committee work and in activities to promote physics in a broad context. This report intends to give a short presentation also of those activities. We also mention some of the priority areas of the University and the Research Council of Norway in which the Department is involved. Effort is continuously brought into multifaculty areas like medical technology, nanotechnology, materials sciences and neuroscience. This multidisciplinary approach is in line with the strategies of our University.

Trondheim, May 2006

Anders Johnsson
Bjørn Torger Stokke

STAFF

Head of Department:
Professor Anders Johnsson (until July)
Professor Bjørn Torger Stokke (from August)

Deputy Head of Department:
Alex Hansen (until July)
Professor Kåre Olaussen (from August)

Permanent staff

Scientific staff:

Professors
Jens O. Andersen, Anne Borg, Arne Brataas, Catharina Davies, Arnljot Elgsæter, Kristian Fossheim, Jon Otto Fossum, Alex Hansen, Eivind Hiis Hauge, Randi Holmestad, Ola Hunderi, Johan S. Høye, Anders Johnsson, Michael Kachelriess, Berit Kjeldstad, Hans Kolbenstvedt, Mikael Lindgren, Tore Lindmo, Ole J. Løkberg, Thor Bernt Melø, Arne Mikkelsen, Frode Mo, Jan Myrheim, Kalbe Razi Naqvi, Kåre Olaussen, Steinar Raaen, Emil J. Samuelsen, Bo-Sture Skagerstam, Helge R. Skullerud, Bjørn Torger Stokke, Asle Sudbø, Jan Swenson, Arne Valberg.

Associate professors
Tore H. Løvaas, Pawel Sikorski, Knut Arne Strand, Jon A. Støvneng, Bård Tøtdal, Erik Wahlstrøm, Sigmund Waldenstrøm, Turid Worren, Ingjald Øverbø.

Adjunct professors
Kenneth Dahl Knudsen, Einar Rofstad, Arne Skretting, Roger Sollie, John Walmsley, Tor Wøhni.

Technical and administrative staff:

Head of Administration
Sylvi Vefsnmo

Administrative staff
Margit C.Hagen, Inger Kosberg, Inger J. Lian, Eli Monsøy, Tove G. Stavø

Technical staff
Irene Aspli, Lars Berntzen, Rolf Dahl, Knut R.Gjervan, Oddbjørn Grandum, Tor Jakobsen, Dagfinn Johnsen, Erling Kristiansen, Lise Kvalø, Per Magne Lillebekken, Heimir Magnusson, Arne Moholdt, Jon Ramlo, Inge Sandaunet, Bertil O. Staven, Kristin Grendstad Sæterbø.

Temporary staff:

Senior staff
Johannes Falnes, Per C. Hemmer, Knut Lønvik, Jørgen Løvseth, Kjell Mork, Haakon Olsen, R. Svein Sigmond, Ivar Svare.

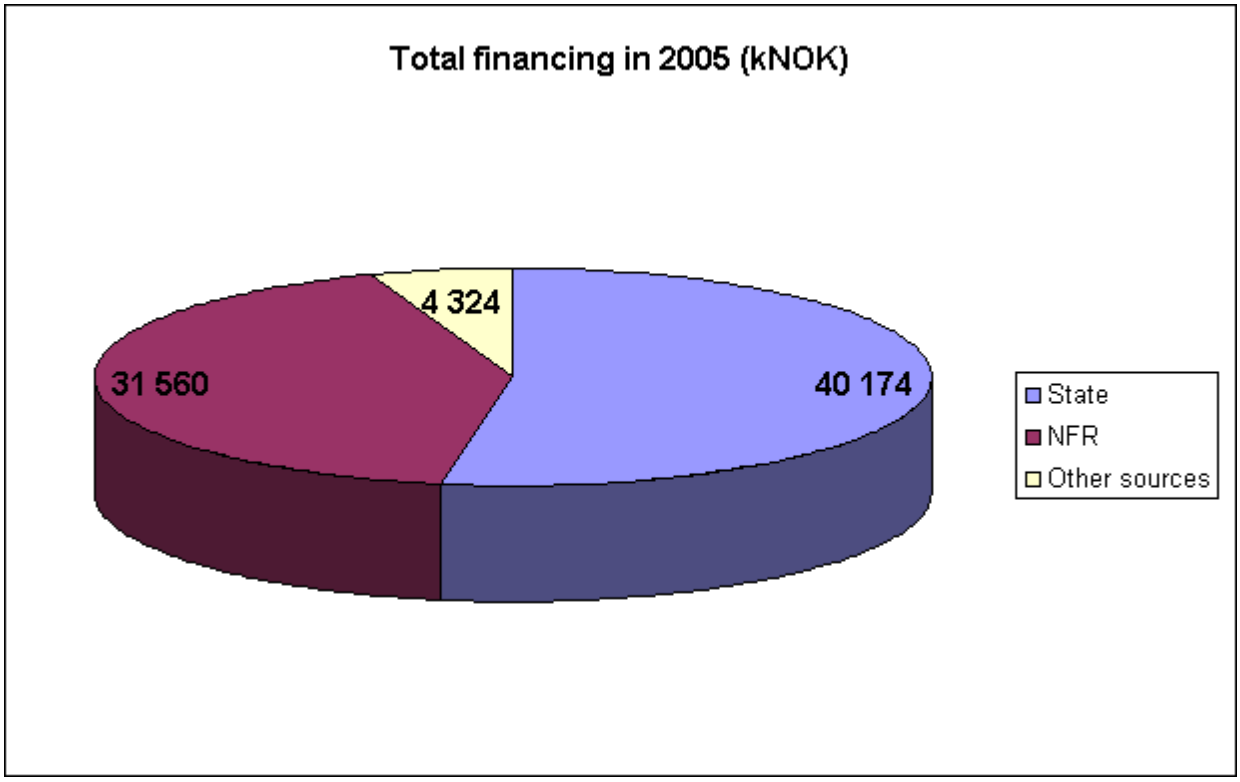
Post doc/research scientist
Trine Højberg Andersen, Egor Babaev, Jon Are Beukes, Ahmed Gmira, Antonius Helvoort, Daniel Huertas-Hernando, Joakim Hove, Morten Kildemo, Joachim Mathiesen, Gjertrud Maurstad, Yves Meheust, Boris Minaev, Anh Kiet Nguyen, Stine Nalum Næss, Sverre Vegard Pettersen, Ståle Ramstad, Albert Reiner, Bjørn Skjetne, Pradhan Srutarshi, Ingunn Tufto, Rene Vissers, Per Erik Vullum, Roland Wittje.

Doctoral students
Christian Andresen, Asadollah Bagheri, Jan Øystein Haavig Bakke, Tom Kristian Bardal, Bjørn Åge Bergsjordet, Binod Kumar Bhattarai, Torkel Bjarte-Larson, Håvard Huru Bergene, Øyvind Borck, Kjetil Børkje, Aktor Chikukwa, Eskil Kulseth Dahl, Live Eikenes, Arne Erikson, Tom Richard Evensen, Davi de Miranda Fonseca, Jørn Foros, Martin S. Grønsleth, Henning Frydenlund Hansen, Fredrik Hansteen, Håkon Kortner Hasting, Hans Kristian Helgesen, Mari Juel, Steinar Kragset, Jacob Rune Linder, Yun Liu, Lars Løseth, Devi Dhavraj Meena, Samsun Mohamad, Jan Petter Morten, Heidi Nordmark, Kanak Parmar, Amutha Ramachandran, Thomas Ramstad, Ole Christen Reistad, Nina Kristine Reitan, Inger Rudvin, Terje Røsten, Stein Olav Skrøvseth, Roman Shchelushkin, Hans Joakim Skadsem, Marit Sletmoen, Jo Smiseth, Eivind Smørgrav, Bjarte Gees Bokn Solheim, Frantz Stabo-Eeg, Aksel Straume, Trude Elna Støren, Ingeborg-Helene Svenum, Oddbjørn Sæther, Torbjørn Sund, Sven Tierney, Sedsel Fretheim Thomassen, Henrik Tollefsen, Wakshum M. Tucho, Per Erik Vullum, Lars Erik Walle.

ACCOUNTS 2005

		Amount KNOK
Government University funding		**40 174**
Projects financed by the Research Council of Norway	**Project manager**	**Amount KNOK**
Structural, electronic and optical properties of atomic overlayers on surfaces	Anne Borg	208
FUNMAT, post.doc.	Anne Borg	635
FUNMAT, PhD student	Anne Borg	512
Fysikkåret 2005	Anne Borg	699
Quantum Transport in Nanoscale Systems	Arne Brataas	13
Transport of spin and charge in semiconductors	Arne Brataas	466
Fundamentals of Nanoscale systems	Arne Brataas	1 241
Fundamentals of Condensed Matter	Arne Brataas	1 734
Intravital microscopy and MRI	Catharina Davies	486
Nanostructured Soft and Complex Materials	Alex Hansen	3 894
Experimental investigations	Jon Otto Fossum	567
Structure and Dynamics of Soft and Complex Nanomaterials	Jon Otto Fossum	904
SUP Complex	Jon Otto Fossum	429
PhD student, H.H.Bergene	Alex Hansen	460
Two-Phase Flow	Alex Hansen	491
Petromax	Alex Hansen	404
The Role of Damage in Fracture Dynamics	Alex Hansen	631
Fracture-Failure Phenomena in Disordered Media	Alex Hansen	582
Micro- and nanostructure, materials development	Randi Holmestad	2 327
FUNMAT, PhD students	Randi Holmestad	506
Light Metal Surface Science	Ola Hunderi	129
Dendritic nanoporous materials with multifunctionality	Mikael Lindgren	1 702
Forskningssamarbeid Norge - Tyskland	Mikael Lindgren	20
Heat treatment fundamentals	Randi Holmestad	2 409
Electromagnetic fields and biological effects	Anders Johnsson	275
Factors controlling UV radiation in Norway	Berit Kjeldstad	351
Material fluxes from the Russian Rivers Ob and Yenisey	Berit Kjeldstad	110
Travel support SNBL/ESRF	Frode Mo	442
Mesoscale structures	Bjørn T. Stokke	163
Polymer gel signal transducers	Bjørn T. Stokke	490
Structure Formations and Properties of Polyelectrolyte Complexes	Bjørn T. Stokke	518
Quantum Transport in Nanoscale Systems	Asle Sudbø	465
Multicomponent Superconductivity	Asle Sudbø	532
IKT-oxides	Asle Sudbø	6 192
Thin-film III-V semiconductors	Turid Worren	409
PhD student Rune Strandberg	Turid Worren	163
	Sum	**31 560**

	Project manager	Amount KNOK
Other external funding in 2005		
EU	Valberg/Kjeldstad/Brataas	234
Statoil	Alex Hansen/Anders Johnsson	159
VISTA	Hansen/Hunderi	74
Photocure ASA	Anders Johnsson	83
Linkøpings university, Uppsala	Mikael Lindgren	318
FOI, Totalforsvarets foskningsinstitutt	Mikael Lindgren	471
Medical tecnology	Tore Lindmo	50
NUFU	Jørgen Løvseth/T.Worren	765
Hydro	Randi Holmestad	1 250
Elkem	Randi Holmestad	250
SINTEF	Knut Arne Strand/Steinar Raaen	338
Statens Strålevern	Tor Wøhni/Berit Kjeldstad	115
IFE	Johnsson/Vefsnmo	258
Post- og teletilsynet	Anders Johnsson	100
Statnett SF	Anders Johnsson	60
Telenor ASA	Anders Johnsson	35
	Sum	**4 324**
Total external financing in 2005		**35 884**



AWARDS

Professor Asle Sudbø (number two from left) was awarded the Møbius prize for the year 2005 by the Research Council of Norway. Sudbø was awarded the prize for his high-quality publications within teoretical condensed matter physics.

Professor Mikael Lindgren (right) was awarded a prize for outstanding pedagogic activities. The NTNU students appointed Mikael Lindgren for this prize, awarded by the Faculty of Science and Technology

Dr.ing. Eivind Smørgrav (left) and dr.ing. Jo Smiseth (right) were awarded Teknas prize for Young Research Scientists for their simulations of properties of hydrogen under ultra high pressure.

Professor Anders Johnsson was awarded the Rimington memorial prize for 2004 at the annual meeting in 2005 at Norsk Forening for Fotobiologi og Fotomedisin. The prize is awarded for research within photobiology and photomedicin as a memory of professor Claude C. Rimington.

The World Year of Physics 2005

UNESCO decided that 2005 should be the World Year of Physics. In 1905 Albert Einstein wrote his legendary articles which provided the basis of three fundamental fields in physics: the theory of relativity, the quantum theory and the theory of Brownian motions. The World Year of Physics in 2005 will provide the opportunity to celebrate the 100th anniversary of this **Miraculous Year** while raising the public awareness of physics.

The Department of Physics was involved in several arrangements related to the World Year of Physics 2005:

26.01 *Hundre år med Einstein*, by Jan Myrheim, Popular scientific presentation at Vitenskapsmuseet, Suhmhuset

03.02 *Nanoteknologi- motefenomen eller sesam-sesam?*" by Kristan Fossheim, NTNU. P2-Akademiet

16.02 *Lysfenomener i naturen* by Ole Johan Løkberg, NTNU. Popular scientific presentation at Vitenskapsmuseet, Suhmhuset

02.03 *Biologiske klokker* by Anders Johnsson. Popular scientific presentation at Vitenskapsmuseet, Suhmhuset

Week 11,13 and 14 Fysikkløypa

06.04 *Kan elektromagnetiske felt gjøre oss syke?* by Gunnhild Oftedal, HIST, Popular scientific presentation at Vitenskaps-museet, Suhmhuset

13.04 *Fysikkens bidrag til medisinske framsteg* by Kristian Fossheim, NTNU. Popular scientific presentation at Vitenskapsmuseet, Suhmhuset

02-03.06 NANOMAT-Birkeland conference 2005

16.06 Publication of "*Naturens kode*"

23.09 Forskningsdagene
23.09 Forskningstorget, NTNU
23.09 "Researchers Night", NTNU

The Physics Trail – "Fysikkløypa"

The first edition of "Fysikkløypa" was arranged during the winter of 2005. Professor Berit Kjeldstad and Associate Professor Per Morten Kind, both at the Department of Physics, initiated the project. They collaborated with Assistant Professor Nils Kristian Rossing at the Programme for Teacher Education, NTNU.

The purpose was to invite twelve years old children to visit NTNU and to experience several kinds of physics experiments. The children were given about 30 quiz-questions, and it was necessary for them to visit various laboratories to do experiments in order to find the answers.

Laboratory at NTNU filled with kids participating in Fysikkløypa.

Fysikkløypa consists of 35 activities in 3.5 hours, including experiments with sound, light, electricity and magnetism. The purpose is to put the pupil's curiosity to test and to make them wonder how the world around them actually works and hence raise their interest in the natural sciences. Physics students at NTNU acted as guides and supervisors for the children.

More than 1100 children from the two Trøndelag counties participated, which is about 20 % of the total. The Department expected about 400 children, but the enormous interest from the schools led to the prolonging of the one week programme to a three weeks event.

Fysikkløypa generated very positive feedback. At the end of every day, we handed out a small questionnaire asking to list the three experiments that they liked the most and to make comments on whatever they might to add. It turned out that the kids were satisfied with the programme. Some even voluntary stated that they had learned a lot during the day. One child expressed that Fysikkløypa had made her aware of what mathematics could be useful for.

One of the most popular exercises was the soldering

One of Trondheim's upper secondary schools has used Fysikkløypa as inspiration to arrange a similar project in which they invite kids from local junior high schools to come over and perform science experiments.

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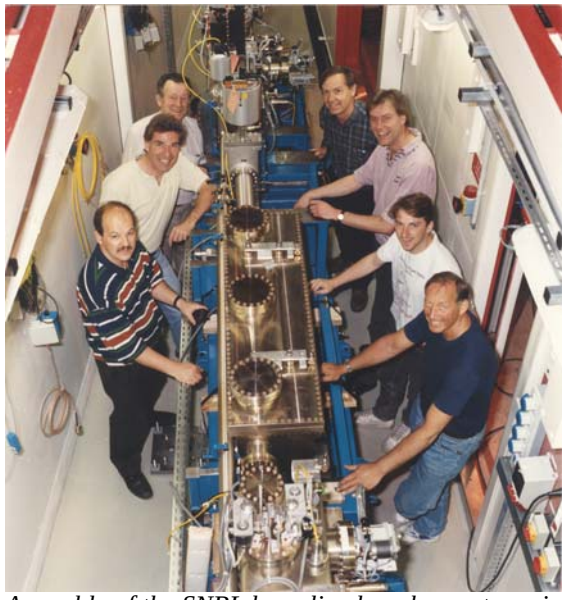
Ten years of synchrotron radiation research in Grenoble

All the time since the official opening of the European Synchrotron Facility (ESRF) and the Swiss-Norwegian Beamline (SNBL) in 1994 and 1995, physicists from our department have been involved in synchrotron-based research in Grenoble. Norway was among the 12 founding members of the ESRF, implying access to all the public beam lines. In addition bending magnet beams were offered by the ESRF for private development by "cooperating research groups" (CRG) from the member countries, of which SNBL is one.

The initiative in Trondheim to form SNBL was taken by F. Mo (Physics) and D. Nicholson (Chemistry), who managed to obtain support by the University in Trondheim (UNIT) and later by the National Research Council. Present Norwegian shareholders of the SNBL are NFR, NTNU, UiO, UiT, UiS and IFE. Initially the SNBL consortium was based on a 72:28 Swiss:Norwegian ratio, being changed to 50:50 since 2002.

The use of the ESRF and the SNBL during the passed years has been satisfactory, and Norway is among the "over-users" in relation to its share. The very first Norwegian ESRF-work, published in 1995, was by a group from our Department. For more details and statistics we may refer to the "Nordsync Annual Reports" and the "Biannual Reports by SNBL".



Assembly of the SNBL beamline by a happy team in 1993.

RESEARCH

DIVISION OF APPLIED PHYSICS AND DIDACTIC PHYSICS

Staff
Professor Berit Kjeldstad
Professor Mikael Lindgren
Professor Ole Johan Løkberg
Professor Helge Skullerud
Ass. professor Per M. Kind (until August)
Ass. professor Tore Løvaas
Ass. professor Thorarinn Stefansson (until March)
Ass. professor Knut Arne Strand
Ass. professor Turid Worren
Professor emeritus Johannes Falnes
Professor emeritus R. Svein Sigmond
Ass. professor emeritus Jørgen Løvseth

Guests:
Scientist Sverre V. Pettersen
Dr. Roland Wittje (Post.doc.)
Dr. Boris Minaev (Scientist)

Overview

This constellation comprises several research teams carrying out research within the fields of *electron and ion physics, energy and environmental physics, experimental optics* as well as *didactic physics*.

There are activities within several different subtopics. In electron and ion physics one studies the electrical breakdown in fluids and gases (*Løvaas, Sigmond)* and transport of ionized gases (*Skullerud)*. The experimental optics group carries out studies of photo-physical properties of molecular systems in biology and materials sciences (*Lindgren*). Thermal fluctuations in mixtures of alkanes and in natural gas in are studied by laser light scattering (*Strand*). Optics research on video holography and optical coherence tomography is also being carried out (*Løkberg)*.

In energy and environmental physics the processes affecting transmission of ultraviolet radiation to the surface, particular the importance of aerosols and clouds, are being studied (*Kjeldstad*), as well as renewable energy sources such as wind, solar radiation and ocean waves *(Løseth, Falnes*). During 2005 a new research team for the development and research on third generation solar cells, was established *(Worren)*.

There is research related to educational physics with particular emphasis on the interaction between practical work and the student's perception on the nature of science (*Kind)*. Development of a learning model adjusted for the situation how to learn through laboratory work (Stefansson) .

For the year 2005 we have chosen to give a more extended and detailed description of one research topic: Light scattering.

Light scattering
(Knut Arne Strand)
In recent years the work performed in the Light Scattering Laboratory has been concentrated on studies of interfaces between gas and condensate phases under reservoir conditions (studies can be performed at pressure up to 700 bar and temperature up to 180 degrees centigrade). In cooperation with SINTEF Petroleum Research we have studied both model systems and real systems from different gas fields in the world, *e.g*. from Norway and the Middle East. The studies have been performed with the purpose of improving condensate reservoir management and production.

However, in 2005 we also have used our interface light scattering spectrometer to study an oil/water interface in connection with Microbial Improved Oil Recovery (MIOR). This work (which has been done in cooperation with Statoil ASA, UNIFOB, and SINTEF Petroleum Research) was performed to find out to what degree stimulating bacterial growth in an oil reservoir may result in an essential reduction of the interfacial tension (IFT) between oil and water. Such a reduction in IFT may cause mobilization of previously capillary trapped oil. A model system consisting of dodecane and nutrient water was studied at ambient conditions. The bacteria used (of the genus Dietzia) are naturally occurring in sea water. The measured IFT versus age of interface is shown in Figure 1 for different flow rates of nutrient water. The IFT was reduced from 38 mN/m to about 0.01 mN/m, which value is to our knowledge, by far the lowest value obtained hitherto for a bacterial system. This large reduction in IFT is an indication of the possible great potential of MIOR.

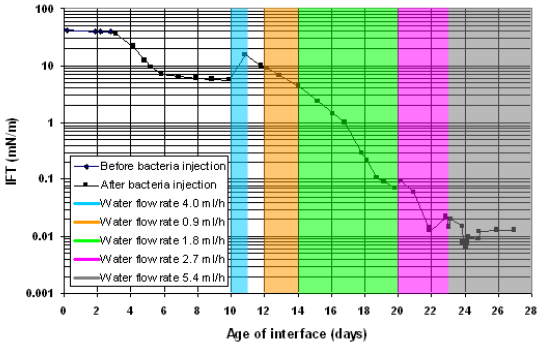


Figure 1: Light scattering measurements of IFT between dodecane and nutrient water at 20.0 °C before (•) and after (■) injection of bacteria versus age of interface. Data points are connected by straight lines. Uncertainty of individual points is typically smaller than the plotted points. Water flow rate regimes are indicated by coloured panes.

The spectrometer used for the studies described above, is shown in Figure 2 below. With this spectrometer we measure light, scattered from thermally excited waves (with amplitude of the order of 1 nm) on the fluid/fluid

interface. Interfacial wave components of different wavelengths are probed by measuring scattered light at different scattering angles. Our spectrometer was designed to measure scattered light over a relatively large range of scattering angles, giving the opportunity to probe interfacial waves with wavelengths from 5 µm to 500 µm.

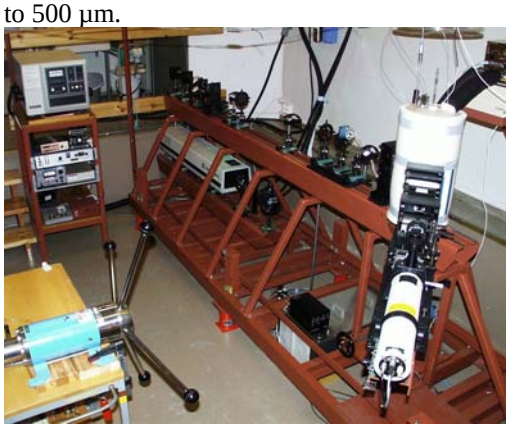


Figure 2: The Interfacial Light Scattering Spectrometer at the Department of Physics.

The intensity of light (measured by counting photons) scattered by a certain interfacial wave has the same time dependence as the wave component amplitude. The information contained in the fluctuating intensity is extracted by computing the degree of correlation between intensities observed at different points of time.

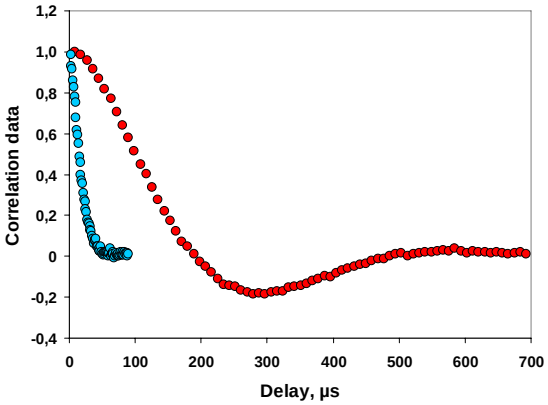


Figure 3: Correlation data for light scattered from interface waves with wavelength 20 m (blue) and wavelength 90 m (red).

Two examples of correlation functions are shown in Figure 3. The correlation functions correspond to light scattered from interfacial waves of wavelength 20 µm and 90 µm. The shape of the correlation function measured for the 90 µm wave reflects that the interfacial perturbations decay as damped oscillations. In this case the restoring capillary force dominates over the viscous damping forces. The near-critically damped correlation function measured for the 20 µm wave corresponds to a situation where the restoring and damping forces are of equal magnitude. The correlation functions are analyzed in terms of hydrodynamic theory to yield information on the interfacial tension and the sum of the viscosities of the adjacent fluid phases. With respect to the data in Figure 1, the example correlation functions in Figure 3 were measured on day 17. Both example correlation functions yielded (within experimental uncertainty) equal values for the IFT (1.02 ± 0.03 mN/m) and the viscosity sum (2.6 ± 0.1 mPa s). Each data point in Figure 1 is based on the analysis of 5-20 such correlation functions measured for wavelengths typically in the range between 20 µm and 100 µm. The correlation data obtained for this bacterial system have been much harder to analyze than usual due to spurious scattering from bacteria colonies on the interface. Therefore, the strong consistency check provided by a wide wavelength range, is essential for such a system.

DIVISION OF BIOPHYSICS AND MEDICAL TECHNOLOGY

Staff
Professor Catharina de Lange Davies
Professor Anders Johnsson
Professor Tore Lindmo
Professor Thor Bernt Melø
Professor Kalbe Razi Naqvi
Professor Bjørn Torger Stokke
Professor Arne Valberg
Ass. professor Pawel T. Sikorski
Professor II Einar Rofstad
Professor II Arne Skretting
Professor II Tor Wøhni

Guests
Gunnhild Oftedal (Scientist)
Dionne Klein (Post. doc.)
Gjertrud Maurstad (Post.doc.)
Marit Sletmoen (Post. doc.)
Ståle Ramstad (Post. doc.)
Ingunn Tufto (Post. doc.)

Overview

The research is divided in three main activities within biophysics and medical technology: *Biopolymers and bionanotechnology:* Studies of physical properties and organisation of biological molecules and their utilisation in bionanotechnological devices. *Medical technology*: Application of molecular and functional imaging to study properties and distributions of molecules in cells and tissue. *Biosystems*: Studies of various kinds, including biophysics of plants, electromagnetic field exposure, space-related research, photosynthesis, and biophysics of vision. A brief overview is given below, and two projects are presented in more detail.

Survey of research activities

Biopolymers and Bionanotechnology

Bionanotechnology
(Bjørn Torger Stokke, Pawel Sikorski)
Research in the field of bionanotechnology focuses on characterisation of natural nanostructured materials and fabrication of nanostructures adopting strategies inspired by nature. Detailed description of such materials will allow for a better understanding of nature's design principles at the nm-scale and may result in novel designs and fabrication strategies. Other research interests in this field include biomineralisation, organisation and processing of biopolymers in nature, crystal structure of polymers and biopolymers, self-assembly and structure of amyloids.

Mesoscale structure formation of biopolymers
B. T. Stokke, M. Sletmoen, G. Maurstad,S. Tierney, S. Danielsen
The function of biopolymers is at large determined by their interaction with other components. One area of research is the determination of the influence of macromolecular properties on the structure formation of condensing semiflexible biopolymers. Polycation-induced DNA condensation is a possible first step in preparing a therapeutic gene for gene delivery. In 2005, we have obtained results elucidating the effects of polycation molecular properties on the relative abundance of the condensed toroidal relative to the linear geometry of the complexes formed when mixing two oppositely charged polymers.

The work performed related to the physical properties of beta glucans focused on determination of the number of parallel chains in the circular macrocyclic topology of these structures, which have a circumference equal to about 150 nm. Aided by AFM (Fig. 1), it was shown that the interaction of polyC with beta-glucan suppressed the formation of the cyclic topology of the beta-glucan.

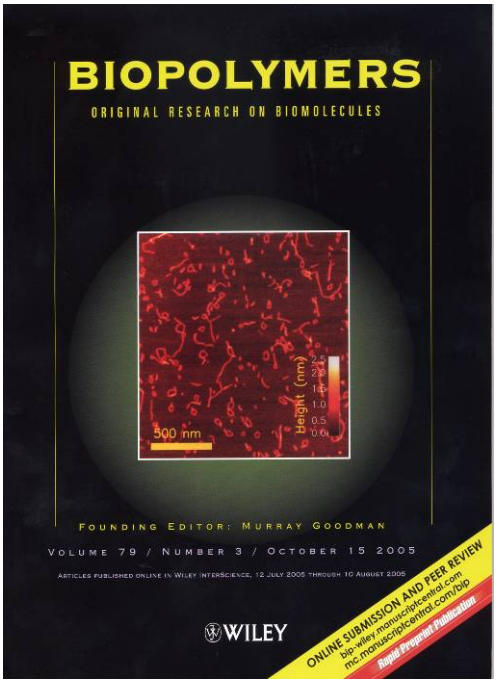


Figure 1. Front cover illustration of Biopolymers showing an AFM topograph of polyC-scleroglucan complexes.

Medical technology

Transport of macromolecules in tumour tissue
(*Catharina de Lange Davies*)
See detailed project presentation below.

Functional optical coherence tomography (OCT)
(*Tore Lindmo*)
OCT has been extended from structural to functional imaging, with a particular application to measure in vivo concentration profiles during uptake of photosensitizers in photodynamic therapy. A PhD thesis was successfully defended in the spring of 2005 within this project.

Biosystems

Plant growth reactions in weightlessness.
(A. Johnsson, B. Solheim)
This study, in collaboration with the Plant BioCentre at the Department of Biology, focuses on gravitational control of growth at the physiological, cellular and genetic level. We are working on hardware for the European Modular Cultivation System (EMCS) that will carry the experiment, scheduled to be flown in 2006. Work is concentrated on techniques to follow growth, rotational and oscillatory plant movements in 3D on centrifuges or in weightlessness. A series of laboratory based experiments are performed simultaneously.

Photoinduced reactions in bacteria.
(A.Johnsson, S. Ramstad, T.B. Melø)
Photosensitization reactions are studied in various cell types. Cells of interest comprise the skin bacterium, *Propionibacterium acnes*, several bacteria of periodontal interest and some cancer cell lines, e.g. the bladder cell line AY-27. The project was outlined in the Annual Report for 2003.

Biological effects of electromagnetic fields
(A. Johnsson, G. Oftedal, A. Straume)
The project concentrates on questions around exposure to weak electromagnetic fields in the low frequency region. A double blind provocation study of possible effects from radio frequency exposure of mobile phones users was finished in collaboration with the Department of Neurology at the University Hospital. This project was presented in the Annual Report for 2004.

Photophysics of important pigment systems
(*Kalbe Razi Naqvi, Thor Bernt Melø*)
Physical properties of water-soluble and water-dispersible carotenoids (including a derivative of astaxanthin that holds promise for cardiprotection) have been investigated. A method for calibrating an integrating cavity absorption meter has been developed, thereby enhancing the sensitivity of absorption spectrophotometry by two orders of magnitude, and making it applicable to scattering samples. Transport of photons and phonons on the nanoscale has been investigated; a new equation for heat conduction by phonons has been proposed, and shown to provide an excellent alternative to more demanding descriptions based on the Boltzmann equation.

Examples of research carried out in 2005

1. Transport of macromolecules in tumour tissue
(Catharina de Lange Davies)
A prerequisite for successful cancer therapy is that the therapeutic agent reaches its target. Novel cancer therapeutic agents such as DNA vectors, liposomes, and proteins are large molecules, and the tumour

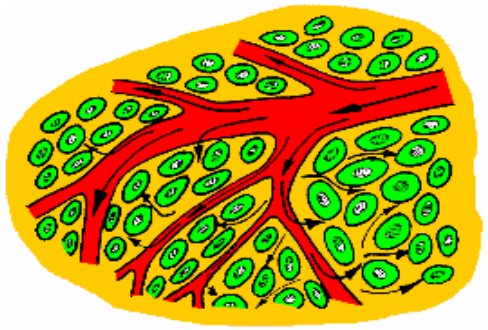


Figure 2. Illustration of transport of therapeutic molecules, which depends on vascular network of the tumor, transport across the capillary wall, and transport through the interstitium.

uptake of these agents is generally too low for successful therapy (Fig 2). The high interstitial fluid pressure and the extracellular matrix (ECM) are potent barriers to the delivery of therapeutic macromolecules. It is not clear whether the structural network of fibrillar collagen or the glycosaminoglycan gel plays the most important role in limiting the uptake of macromolecules. To test this, the effects of the two enzymes collagenase and hyaluronidase which degrade the ECM have been studied with respect to the three main transport steps: 1) The transcapillary pressure gradient by measuring the interstitial fluid pressure and microvascular pressure in human osteosarcoma xenografts (Cancer Res. 64, 4768, 2004, Br.J.Cancer 93, 81, 2005). 2) Diffusion measured by two-photon excitation and fluorescence recovery after photobleaching. A model to measure 3D diffusion using a scanning IR laser has been developed, and confirmed experimentally. 3) The vascular network and transient perfusion is studied by confocal laser scanning microscopy after sequential staining of vessels (AACR 2005). In conclusion destroying the structural protein network seems to be more efficient than degrading the gel of hyaluronan with respect to increasing the uptake of therapeutic macromolecules in tumour tissue.

In 2005 we also have focused on studying the structure and the impact of the collagen network on diffusion of macromolecules. Gels of collagen were used as a model for ECM, and the collagen network visualised by confocal reflection microscopy. The collagen network was physically modulated by a magnetic field and flow into a capillary tube, and chemically modulated by adding the proteoglycan decorin. The physical modulation induced an orientation and alignment of the collagen fibres (see Fig. 3), and the chemical modulation reduced the diameter of the fibres. However, such modulations seem to have little impact on the diffusion of macromolecules in the gel.

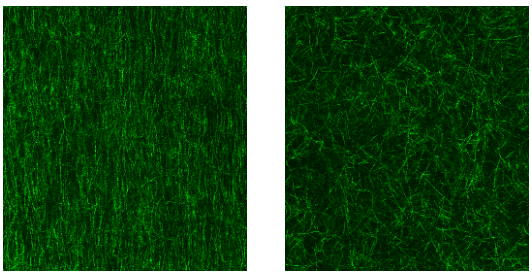


Figure 3. Aligned collagen fibers (left) and random collagen fibres (right).

In tissue (frozen section of rat tail tendon) collagen has been studied using second harmonic generation (SHG), which is a non-linear coherent process where two incident photons of frequency ω are converted into a single photon of twice the frequency 2ω. The second order susceptibility $\chi_{ijk}^{(2)}$ may represent a quantitative measurement of SHG. It is a parameter characterising structure, orientation and nonlinear behaviour of a material. We have developed a method to quantitate the collagen structure by $\chi_{ijk}^{(2)}$. A pulsed IR laser was used to generate the second harmonic signal. The sample was rotated 2π and the SHG recorded every 10º. Based on this a polar plot was obtained for a region of interest and this polar plot was used to determine $\chi_{ijk}^{(2)}$ (see Fig. 4 below). Such measurements may provide unique fingerprint data and be of diagnostic value in assessing normal versus pathological conditions.

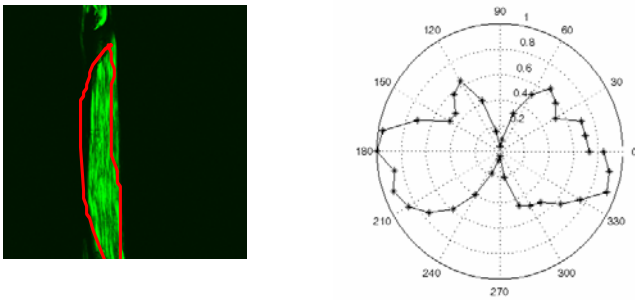


Figure 4. Region of interest and polar plot of SHG signal intensity.

2. Multifocal electroretinogram (mfERG)
(A. Valberg, I. Rudvin)
When stimulating the retina by rapid modulation of light, the rate of light absorption in each cone type can be modulated selectively by carefully controlling the chromatic- and luminance modulation of the stimulus. Cone-isolating stimulation refers to a situation where only one cone type (L, M or S) is modulated while the quantal absorption in the other two cone types is negligible. Studies of cone-isolating full-field rapid flicker electroretinograms (ERGs) have indicated that certain retinal diseases affect the temporal phase of the flicker ERGs differently depending on whether the stimulus is L-cone isolating or M-cone isolating.

The traditional full-field ERG technique is relatively insensitive to effects of disease that manifest themselves only in the central region of the retina, such as AMD. In contrast, a relatively recently developed technique, the multifocal ERG (mfERG), provides a topographical map of response contributions from the central region of the retina, potentially allowing a comparison of AMD-affected and non-affected retinal regions in the same eye. See Fig. 5.

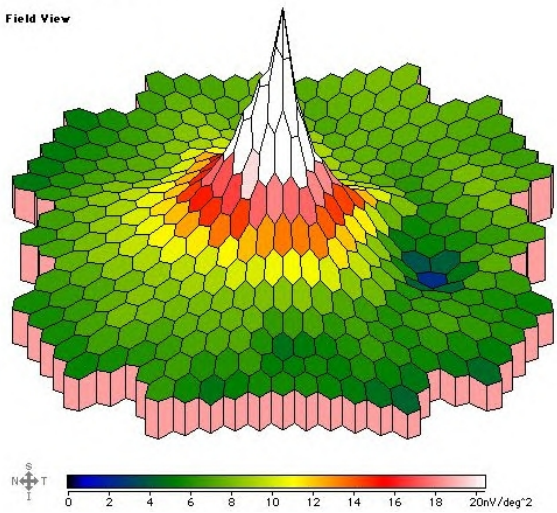


Figure 5. This colour-coded image maps the normal response topography of multifocal electroretinograms. Potentials were recorded during sequential light stimulations of several hundred small hexagon patches imaged on the human retina. The white top represents the magnitude of the activity of the central fovea, and zero potential (blue) is for the blind spot.

We set out to determine whether AMD, too, could be shown to have differential effect on the phase of ERG responses to L- versus M-cone isolating stimulation. Only one group had previously reported multifocal ERGs to cone-isolating stimulation. In subjects with normal trichromatic and dichromatic vision, we were able to record mfERGs to L- and M-cone isolating stimulation with amplitudes and cone-specific characteristics similar to those previously reported. However, the signal-to-noise ratio of the mfERGs, limited by the luminance and colour gamut of current display technology, proved insufficient to allow a topographical mapping of response timing with the required temporal resolution.

DIVISION OF COMPLEX MATERIALS

Staff
Professor Arnljot Elgsæter
Professor Jon Otto Fossum
Professor Alex Hansen
Professor Arne Mikkelsen
Professor Frode Mo
Professor Steinar Raaen
Professor Bo-Sture Skagerstam

Guests
Jon Are Beukes (Scientist)
Ahmed Gmira (Post.doc.)
Yves Meheust (Post.doc.)
Morten Kildemo (Post.doc.)
Stine Nalum Næss (Post.doc.)
Srutarshi Pradhan (Post.doc.)
Bjørn Skjetne (Post.doc.) (From July)

Overview

The research is focused on the *Physics of Soft and Complex Material*s including *Biological Physics*. The phenomena studied include: The structure and dynamics of nanostructured surface alloys; Structural phase transitions in ferroic compounds, clay containing systems and biopolymers; Electro-rheological properties and diffusion properties of natural and synthetic clay particles; Folding and conformational dynamics of proteins and other biopolymers; Anomalous diffusion processes; Mechanical properties of rough surfaces; Brittle fracture; Mechanical properties of granular media; Multiphase flow in porous media.

The research comprises the use of experimental methods, computer simulations and theoretical methods.

The *home laboratories* of the division contain facilities for: Solid state surfaces in ultrahigh vacuum; Wide-angle x-ray scattering; Static and dynamic light scattering; Light microscopy; Atomic force microscopy; Preparation of soft aqueous samples for transmission electron microscopy; Measurements of static and dynamic viscoelastic properties of soft materials (rheology); Micro- and nano-calorimetry; Thermo-gravimetry; Studies of dynamic electro-optic properties of soft materials; Isolation and purification of nanoparticles including biopolymers. Some members of the section are also regular users of the synchrotron facilities in Grenoble, France and at Sao Paulo, Brazil.

The *computer simulation methods* include Brownian dynamics, Monte Carlo and deterministic particle dynamics methods.

The *theoretical studies* are mainly on condensed matter physics theory and statistical physics.

Survey of research activities

Experimental and theoretical studies of biopolymer dynamics and structure

(*A. Elgsæter and A. Mikkelsen*)

Our work within the physics of various biopolymer systems consists of three closely integrated parts: I) Development of the necessary formal theoretical basis for describing the nanoscale dynamics using realistic macromolecule models. II) Development of the required numerical algorithms to carry out numerical Brownian dynamics simulation of macromolecule dynamics. III) Experimental studies of macromolecule dynamics using methods such as static and dynamic light scattering, and electrically induced transient birefringence. A primary goal here is a deeper understanding of the interplay between functions and structural dynamics.

One important work in 2005 is the fully upgrading of the freeze-etch apparatus used for the preparation of soft aqueous samples for transmission electron microscopy (see Figs. 1 and 2). The freeze-etch apparatus can make platina replica with a lateral resolution of 1-2 nm for studies of biopolymers, lipid micelles and lipid vesicles. This is the only instrument in Norway of this kind.

Fig. 1 The freeze-etch apparatus build at Department of Physics. Most of the essential parts are renewed and improved during 2005.

Fig. 2. The knife and specimen holder (for four specimens) in the chamber of the freeze-etch apparatus are cooled to temperatures near liquid nitrogen temperature.

Experimental investigations of soft and complex materials: From nano to macro.
(*J. O. Fossum*)
The research group has during several years focused on basic understanding of problems within soft and complex materials, in particular physical phenomena in soft matter using synthetic nano-layered silicates (clays) as the physical complex model system. Main physical phenomena studied in these systems include flow and diffusion processes, intercalalation processes, liquid crystalline phases in systems of nano-platelets, and electrorheological and magnetorheological smart material properties. Important experimental methods applied include standard microscopy, as well as AFM and STM, rheology in external applied fields (Magnetic or Electric), visible light scattering, synchrotron x-ray scattering (at ESRF, LNLS in Brazil, and other sources), and neutron scattering (mostly at IFE, Kjeller). A new rotating anode Bruker Nanoatar SAXS system was installed in 2005, and is now operational.

Brittle fracture, mechanical properties of granular media, two-phase flow in porous media, econophysics
(*A. Hansen*)
The main research effort this year has been focused on problems concerning the scaling properties of brittle fracture surfaces. We have found a very efficient method to identify so-called anomalous scaling, where more than one roughness index is needed to characterize a fracture surface. We have continued our work on the theoretical foundation for the scaling properties of brittle fracture surfaces, and have found a criterion based on monitoring damage bursts to determine whether a system is about to fail catastrophically or not. The black-out statistics of the Norwegian high-voltage power grid was analysed, and a model was constructed that captures the important features observed. The black-out distribution follows a power law.

In porous media, we have studied the cluster structure of immiscible two-phase flow under steady-state conditions. The work on granular media in connection with metal printing continues, and so does the work on network topology.

Crystallographic studies of ferroic materials, instrumentation
(*F. Mo*)
Research involved studies of structural phase transitions in two organic ferroic hydrates: one ferroelectric compound with a phase transition driven by T (Rochelle salt), and one alleged ferroelastic compound with a phase transition presumably induced by mechanical stress (a hydrated glucose complex). A gas-flow thermostat (Peltier elements) sample cell with control of relative humidity was constructed previously for diffraction experiments with crystals that are unstable and denature easily upon changes in temperature and/or relative humidity under X-radiation. This cell was essential for the successful studies of the two compounds. A unique feature of the cell is a transparent, rotatable capacitor allowing an electric DC-field to be applied to the crystal in a fixed crystallographic direction during the experiment. In 2005 the capacitor geometry has been modified to accommodate plate-shaped ferroelectric samples of thickness ~ 500 μm carrying epitaxial thin films. First tests have given very promising results showing the response of both film and substrate structure under the impact of DC fields up to 2000 V/cm.

Properties of nanostructured surfaces
(*S. Raaen*)
Electronic and structural properties of nanostructured surfaces are studied by X-ray photoelectron spectroscopy (XPS), ultraviolet photoelectron spectroscopy (UPS), photoemission electron microscopy (PEEM), low energy electron diffraction (LEED, and temperature programmed desorption (TPD). In recent years focus has been on growth and properties of rare earth/transition metal based surface alloys, e.g. Ce, Sm and Tm on Pt, Pd and Rh. Adsorption of simples gases has shown adsorption properties may be dramatically altered on such systems. Some progress has recently been made in analyzing TPD data by use of Monte Carlo simulations. Presently, we are also studying the properties of a new form of carbon, namely carbon nano-cones, which e.g. show some interesting gas adsorption properties.

The Quantum Human Eye
(*Bo-Sture Skagerstam*)
We model photon detection processes and signal information processing in the human eye in terms of a single-photon detector device. We can then raise and answer questions like signal-to-noise ratios, spectral dependence, low-photon number detection efficiencies and similar issues. Results of calculations, see Fig.3, showing that it is difficult to discriminate between a source with an exact number of photons and a Poissonian distribution of photons, i.e. single photon-detection cannot be completely settled using our procedure.

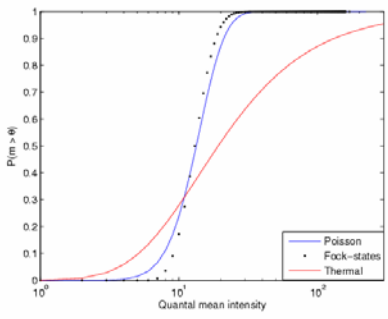


Fig.3 The results of a calculation of the cumulative detection probability of more then a threshold number θ *of single-mode photons as a function of the photon density, chosen to be proportional to the average number of photons of the source.*

A comparison with a thermal source of photons leads to a clearer difference in the response in the human eye. We have performed similar, more detailed calculations for multi-mode photons with similar results. In a simple model we have also been able to show that noise is required in order to optimize the signal-to-noise ratio in the human eye.

Example of research carried out in 2005

Valence variations of samarium on silver surface alloys

By Mari Juel, Morten Kildemo and Steinar Raaen

Thin deposited films of samarium on polycrystalline silver are investigated by X-ray photoelectron spectroscopy (XPS), ultraviolet photoelectron spectroscopy (UPS) and photoemission electron microscopy (PEEM). The Sm valence is mainly divalent for low Sm coverage, while the trivalent contribution to the XPS intensity increases considerably for higher coverage.

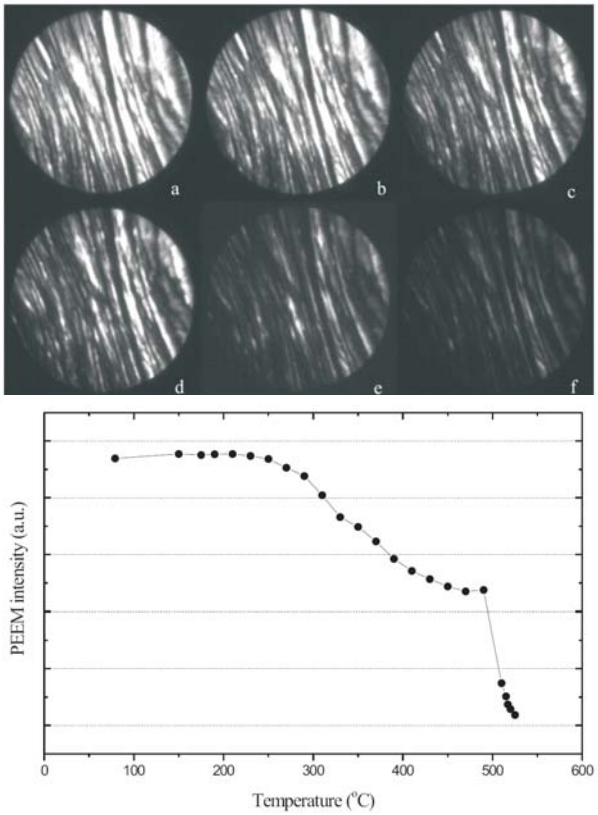


Figure 4. The upper photograph shows six PEEM images at temperatures: (a) 150, (b) 310, (c) 410, (d) 490, (e) 510, and (f) 525 C. The effective thickness of the samarium layer was 2.6 Å. The diameters of the images are 440 μm. The graph below shows the averaged intensity of the images, illustrating changes in work function as the sample is annealed

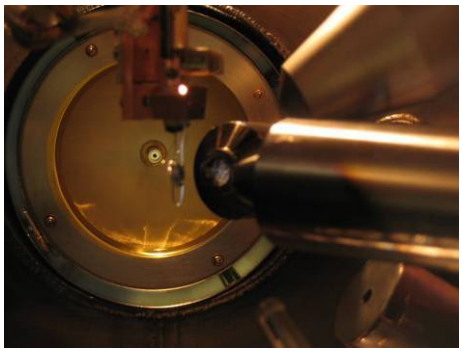


Figure 5. The sample and probes for low energy electron diffraction, x-ray photo-emission and ion-sputtering in the ultra-high-vacuum chamber.

For a samarium overlayer thicker than 4 Å, the average valence is estimated to be 2.65. The mixed valence in this system is concluded to be heterogeneous (all Sm atoms have integer and site-dependent valence). Alloy formation between Sm and Ag is observed upon annealing to temperatures between 400 and 550 C. For these temperatures the change in average Sm valence is dependent on the initial Sm coverage deposited onto the Ag-foil. Systems with low initial coverage exhibit an increase in the average valence, while a decrease is observed for systems with coverage above 6 Å. For intermediate coverages around 3 Å an initial decrease in average valence is followed by a rapid increase for temperatures above 400 C due to morphological changes in the surface layer.

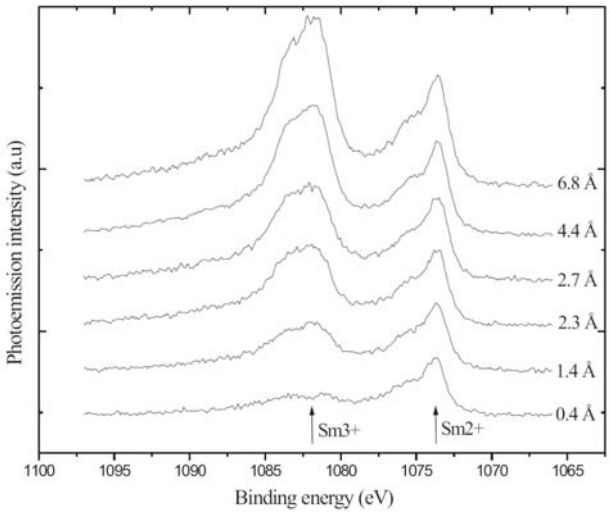


Figure 6. Sm $3d_{5/2}$ XPS-spectra of increasing overlayer thickness of Sm deposited onto a Ag-foil at 50 C. The divalent and trivalent species are marked in the figure as Sm2+ and Sm3+

DIVISION OF CONDENSED MATTER PHYSICS

Staff
Professor Anne Borg
Professor Kristian Fossheim
Professor Randi Holmestad
Professor Ola Hunderi
Professor Emil J. Samuelsen
Professor Jan Swenson (Febr. – July)
Assistant professor Bård Tøtdal
Assistant professor Erik Wahlström
Professor II John Walmsley
Professor emeritus Ivar Svare

Guests
Dr. Trine Andersen (Post.doc.)
Dr. Ton van Helvoort (Post.doc.)
Dr. Nils Sandberg (Post.doc.)
Mr. Bjørn Soleim (Siv.ing.)
Dr. Rene Vissers (Post.doc.)
Dr. Per Erik Vullum (Post.doc.)

Survey of research activities

The research activities include topics in experimental Condensed Matter Physics. The members of the division work with a variety of experimental techniques,including synchotron radiation, for studying physical properties of materials and material structures. A brief survey of the research is given. For the year 2005 two research projects are described in more details.

Transmission electron microscopy (TEM)

(*R. Holmestad, B. Tøtdal, J.Walmsley*)
The activities in the TEM research group include nanoscale structure studies within materials physics and the connection to macroscopic properties.
In 2005 projects have included:
* Micro/nano structure studies of functional perovskite materials: ferroelastic sintered materials, ferroelectric thin films and one dimensional structures
* Materials for hydrogen storage (alanates) - nanoscale structure and distribution of catalyst additives.
* Analysis of alloy nanoparticles and support in catalyst materials
* Alloy development, nucleation of precipitates in aluminium alloys; structure determination of metastable, hardening phases.
* Silicon solar cell material, hydrogen diffusion and defects in single crystal silicon and defects and impurities in multicrystalline silicon solar cell materials
* Palladium membranes for hydrogen separation, evolution of microstructure related to function of material
* Corrosion properties of surfaces, correlation of trace impurity segregation and electrochemical properties of aluminium alloys
* High temperature corrosion of steels, metal dusting corrosion processes in industrial plant for methanol production
*Atomistic modelling and *ab initio* methods in materials science

FE-TEM offers a small probe and possibilities of energy filtering, spectroscopic imaging and X-ray mapping from miniscule regions. In 2005 we have developed the scanning TEM technique, which offers Z-contrast at atomic level. The group runs a strategical university program (SUP) 'Nano- and micro-structure based materials development' and is strongly involved in the competence project (KMB) 'Heat treatments fundamentals' on aluminium alloys. There is also strong interaction with PhD students from other departments through the Light Metal Surface Science programme and Thermotech KMB.

Polymeric and molecular organic semi-conductors

(*E. J. Samuelsen*)
The research has focussed on self-assembling of organic semi-conducting polymers deposited as thin films. In a joint work with Risø National Laboratory stereoregular polyhexylthiophene (PHT) was deposited on aligned sheets of teflon, thereby obtaining layers of doubly preferred orientation: The resulting thin films thus possess a single-crystal-like property, allowing more detailed structural insight, as obtained by x-ray diffraction.

At NTNU studies were performed to check whether there would be an effect by *aromatic* substrates on the self-organisation of thin layers. Comparative studies were carried out for stereo-regular and non-stereo-regular poly-octylthiophenes (POT) on pyrolythic graphite and on mica (muscovite), and the degrees of preferred orientation were determined by x-ray diffraction. An important finding is that the POT films get quite firmly attached to the graphite substrate, and that the tendency of deposition with the thiophene ring parallel with the substrate surface is appreciably stronger for the graphite substrate. The reason for this effect is believed to be an affinity between the π-electrons of the thiophene ring and those of the aromatic graphite carbon hexagons.

A small-angle x-ray scattering instrumentation (SAXS), of the trade mark Bruker NANOSTAR, was installed at the rotating anode x-ray generator. It is being used for studies of long-period materials and of inhomogeneities in polymers and other soft materials.

Light scattering from rough surfaces

(*Ola Hunderi, Ingve Simonsen and Thomas Berg*)
A Monte Carlo simulation has been used in the study of light scattering from randomly rough surfaces. Both s- and p-polarized light has been studied. The method consists of numerically generating surface realizations which possess a given pre-determined power spectrum. Then the reduced Rayleigh equation, an integral

equation determining the reflection amplitude R(k|q) is solved numerically. By introducing cutoffs in the *q*-integral sufficiently far into the evanescent regions of *q*-space, and thereby being able to represent the integral by a finite discrete sum, a set of linear equations is obtained. The contribution to the mean differential reflection coefficient from both the coherently and incoherently scattered light can be obtained. It is demonstrated thatfeatures of the incoherent contribution ($\partial R_v/\partial\theta)_{incoh}$, such as the well-known enhanced backscattering peak, can be found in good agreement with experimental results. It is also demonstrated that when light is scattered on surfaces possessing the West-O'Donnell spectrum, the contribution to $(\partial R_v/\partial\theta)_{incoh}$ from single scattering events vanishes around the specular reflection direction.

Adsorption of 1,1-dichloroethene on the Si(111)-7x7 surface

(*Trine H. Andersen and Anne Borg*)

The interaction between 1,1-dichloroethene and the Si(111)-7x7 surface has been investigated by photoemission spectroscopy, performed at the MAXII synchrotron radiation laboratory, Lund University. Sweden. 1,1-dichloroethene adsorbs dissociatively at room temperature in two different configurations where one or both C-Cl are broken. We find that 30% of the molecules chemisorb by breaking one C-Cl bond and 70% of the molecules by breaking both C-Cl bonds. Upon adsorption at 100K a physisorbed 1,1-dichloroethene layer is formed. Similar to observations for these molecules in the gas phase, the intensity ratios of the carbon contributions to the photoemission spectra do not reflect the chemical composition of the molecules. Theoretical modelling is underway to address this question.

This work was done in collaboration with Department of Chemistry, University of Bergen.

Examples of research carried out in 2005

1. Ferroelastic $LaCoO_3$-based polycrystalline ceramics

By P.E. Vullum and R. Holmestad

$LaCoO_3$-based ceramics are potential candidate materials for dense membranes for oxygen separation and partial oxidation of natural gas, as well as potential cathode materials in solid oxide fuel cells. Satisfying mechanical properties are one of the major challenges. The materials are ferroelastic with a hysteresis between stress and strain, and the ferroelastic behaviour has shown to affect the E-modulus, bending strength and fracture toughness.

Rhombohedrally distorted $LaCoO_3$-based materials were studied using transmission electron microscopy (TEM), *in situ* synchrotron X-ray diffraction during uniaxial compression/decompression, and *ex situ* X-ray diffraction after compression. In addition, macroscopic stress-strain behavior was measured. Focus was on the understanding of the ferroelastic behavior as a function of stress, chemical composition and temperature, from the atomic to the macroscopic scale.

Twin structures with ferroelastic twin walls, parallel to the pseudo cubic {100} and {110} planes, were present from the atomic to the micrometer scale in the materials. (100) type of twins are shown in the TEM bright field image in Fig. 1. An external mechanical stress field can reorient the domain structure, and in Fig. 2, the intensity of selected diffraction lines were followed as a function of increasing stress. In the direction parallel to the external stress axis, diffraction intensities with large values of the Miller index l, compared to h and k, increase with increasing stress. The opposite trend is observed in the direction perpendicular to the stress axis. This shows that the domains reorient with the purpose to align the unique hexagonal c-axis parallel to the direction of the external field. The creation of ferroelastic domains releases much of the inherent strain, caused by the second order paraelastic to ferroelastic phase transition. The ferroelastic domain reorientation under external stress serves as a toughening mechanism since energy is dissipated through creation and movement of domain walls.

This work is done in collaboration with J. Mastin, M.-A. Einarsrud and T. Grande at the Department of materials Science and Engineering, NTNU.

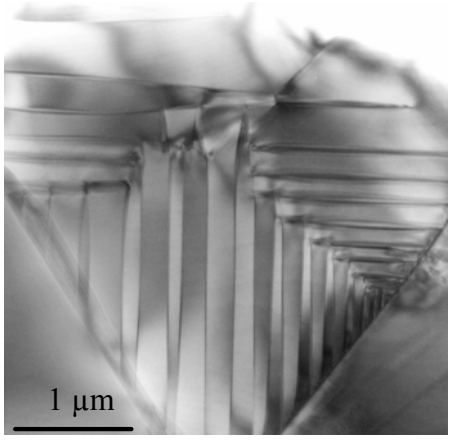


Figure 1. (100) twins in two perpendicular pseudo cubic [100] directions in $LaCoO_3$.

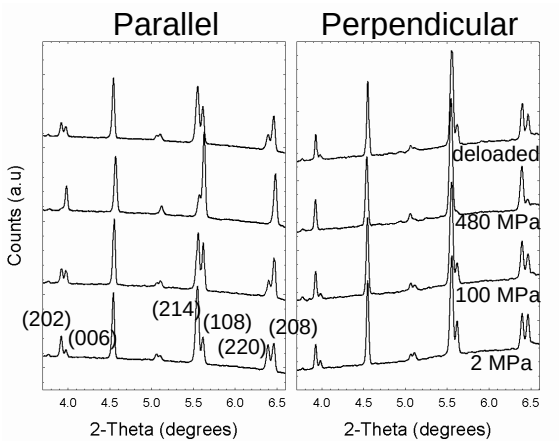


Figure 2. X-ray diffraction patterns of $La_{0.8}Ca_{0.2}CoO_3$ during a compression/decompression cycle in the parallel and the perpendicular directions.

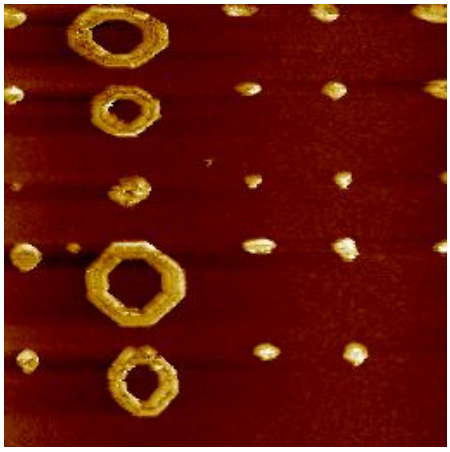


Fig 3. An STM image of a patterned magnetoresistive film with lithographically defined structures of selected geometries (5 5μm^2, U=-0,7 V, I=0,9nA).

This work is done in collaboration with M. Hanson and R. Brucas, Applied Physics, Chalmers Univesrity of Technology.

2. STM for lateral characterisation of magnetoresistivity through point contacts

By Erik Wahlström

We are developing techniques for spin dependent tunnelling microscopy and local transport measurements. This is motivated by the need to understand sub-micron spin devices where the interplay between the different contributions to the magnetic energy of the nanomagnet system and the interaction between the magnetic state of the nanomagnet and the electron spin of the injected current are important.

A UHV scanning tunnelling microscope has been modified for studies in order to characterize well-defined model systems with high lateral resolution. Their magnetoresistive properties can thus be studied by measuring the transport through point contacts formed between tip and sample. Through this technique we image layered nanostructured magnets with the modified microscope (Fig. 3). Simultaneously it is possible to perform point contact measurements to resolve lateral magnetoresistive variations.

In the instrument a continuous magnetic flux density up to 100 mT can be obtained at the sample. Co-variations between the applied field and/or the current or the resistance can be readily measured. Preliminary model systems were studied and optimal measurement procedures are under development.

The growth and lithography of nanomagnetic structures and the re-building of the microscope have progressed in parallel. We have prepared samples specially designed for the instrument, which enable us to readily probe the transport properties of different structures produced under identical conditions. This offers an excellent ground for probing size and shape effects in magnetoresistivity. Initially we have chosen to study samples exhibiting giant magnetoresistive effects (GMR) in a geometry with the current perpendicular to the structures with different layered structures as depicted above.

DIVISION OF THEORETICAL PHYSICS

Staff
Professor Jens Oluf Andersen (from August)
Professor Arne Brataas
Professor Eivind Hiis Hauge (Univ. Rector until July)
Professor Johan S. Høye
Professor Michael Kachelriess (from September)
Professor Hans Kolbenstvedt
Professor Jan Myrheim
Professor Kåre Olaussen
Professor Asle Sudbø
Ass. Professor Jon Andreas Støvneng
Ass. Professor Sigmund Waldenstrøm
Ass. Professor Ingjald Øverbø
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Professor emeritus Per Chr. Hemmer
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Dr. Tommy Øvergård (Scientist)
Dr. Dag Østvang (Scientist)
Daniel Huertas-Hernando (Post. doc.)
Anh Kiet Nguyen (Post. doc.)
Egor Babaev (Post. doc.)

Overview

Research is mainly carried out within the broad fields of *Condensed Matter Physics*, *Statistical Physics*, *Quantum Physic*, *Astro-particle Physics*. These contain several subfields with a large variety of topics for research. A brief overview is given.
Asle Sudbø received the prestigious Møbius prize for 2005, for outstanding research on the theory of superconductivity.

Survey of research activities

Unification of HRT (Hierachical Reference Theory) and SCOZA (Self-consistent Ornstein-Zernike Approximation) has been studied. Both theories have turned out to be very accurate for fluids also in the critical region. The HRT, inspired by the renormalization group approach, adds contributions from wave-vectors of decreasing magnitude to the attractive interaction. SCOZA on the other hand effectively adds amplitude to the interaction (by changing temperature). Both approaches require consistency between two different routes to thermodynamics by which a free parameter can be determined. (*J.S. Høye and A. Reiner*).

The SCOZA is used for further study of lattice gases (or spin systems) and fluids with realistic interactions like the Lennard-Jones interaction. (*J.S. Høye and A. Reiner*).

Further studies of the thermal behavior of the Casimir force between metallic surfaces has been performed (*J.S. Høye, I. Brevik, J.B. Aarseth, K. Milton, V.S. Berntsen, R. Herikstad, S. Skriudalen*).

Our activity focuses on spin and charge dynamics in nanoscale structures. Of particular interest is the spin current induced magnetization dynamics in nano-magnets. This problem is fundamentally challenging because it requires an understanding of the coupling between quasi-particles out-of-equilibrium and the magnetization order parameter and it is commercially interesting because of its potential use in magnetic random access memories. We carry out studies of spin and charge flow in superconductors, normal metals, semiconductors, and ferromagnets. We published nine papers in 2005 of which two in Phys. Rev. Letters (*A. Brataas, J.P. Morten, R. Shelushkin, J. Foros*).

The research has focused on large-scale Monte Carlo simulations of Ginzburg-Landau theories of multi-component (mainly two-component) superconductors, in an external magnetic field. We have found that a two-component superconductor can take up two novel types of quantum fluids: 1) A super-conducting superfluid featuring dissipationless mass flow as well as charge flow. 2) A metallic superfluid featuring ohmic resistance to charge flow while charge-neutral matter can flow without restriction. We have also proposed four experiments to test for these novel quantum fluids. *(A. Sudbø, E. Babaev, K. Børkje, E. Dahl, M. Grønsleth, S. Kragseth, J. Linder, J. Hove).*

Entanglement in mixed quantum states is studied from a geometric point of view (*J. Myrheim, J.M. Leinaas, E. Ovrum).*

We continue to study entanglement in the ground state of a class of models defined by quadratic Hamiltonians. These are finite-size approximations of a corresponding class of quantum field theories. We find the effective Schmidt-number of such states to be smaller than expected, and try to utilize this for more efficient numerical description of such states. (*K. Olaussen and S.O. Skrøvseth).*

We have begun to study quantum field theory in inhomogeneous spacetimes, in particular from the speculative viewpoint that the world we observe may be an interface (a brane) in a higher dimensional universe. (*K.Olaussen).*

We continue to study entanglement in the ground state of a class of models defined by quadratic Hamiltonians. These are finite-size approximations of a corresponding class of quantum field theories. The study of entanglement properties appears to be an efficient way to localize regions of quantum criticality in models in 1+1-dimensional space-time. This is achieved by looking for the known signature of conformal invariance in such regions (*K. Olaussen, S.O. Skrøvseth*).

The physics of massive neutrinos, in particular their electromagnetic properties, is studied (*K. Olaussen, B.L. Hansen*).

Various problems related to polymerization and catalysis are investigated by quantum chemical modeling, e.g. with density functional theory (*J.A. Støvneng).*

We have been studying the phase diagram of QCD at high density by the means of effective theories such as the NJL model. We are in particular focusing on the possibility of color superconductivity as well as the condensation of kaons. We have also examined the thermodynamics of the CP[1] model in 1+1 dimension paying attention to the effects of quantum instantons (*J.O. Andersen, D. Boer, H. J. Warringa*).

We studied neutrinos from supernova (*R.Buras et al.*) as well as galactic sources of high-energy neutrinos (*P.D. Serpico, M. Kachelriess*).

Dilaton emission was used to constrain cosmic superstrings (*E. Babichev, M. Kachelriess*). Ultra-high energy cosmic ray physics was investigated (*P.D. Serpico, M. Kachelriess, D.V. Semikoz, M. Teshima*).

The distribution of the magnitude of burst avalanches in fiber bundles and in systems of electric fuses is studied. In a Physical Review Letter we determined the change in such distributions just before the systems break down, a useful signature of imminent failure (*P.C. Hemmer, S. Pradhan and A. Hansen*).

Examples of research carried out in 2005

Phase diagram of QCD
(J.O Andersen)
Quantum Chromodynamics (QCD) is the theory which describes the quarks and gluons. Since the quarks are interacting strongly, one never observes free quarks in Nature. All quarks are confined inside the hadrons. Hadrons are the states of quarks and observed in e.g. accelerator experiments, for example mesons (e.g. pions) and baryons (e.g. protons and neutrons). If hadronic matter is heated, it is expected to undergo a phase transition to a new state of matter called the quark-gluon plasma. In the quark-gluon plasma the hadrons “melt” and the quarks are no longer confined. In cosmological models, the quark-gluon plasma existed in the early universe. Knowing the properties of this phase of QCD is therefore essential to understanding the evolution of the universe. In order to examine the properties of the quark-gluon plasma, there is currently a large experimental activity aiming at creating it in heavy-ion collisions at Brookhaven and CERN. Similarly, one can ask what happens to strongly interacting matter as one increases the density. In this case, one expects a phase transition to quark matter, in which quarks are no longer confined. If the temperature is sufficiently low, quark matter might also be a color superconductor. The phase diagram at high density (large chemical potential) is very relevant to astrophysics since astrophysical objects such as neutron stars might have a core whose density is so large that it consists of quark matter.

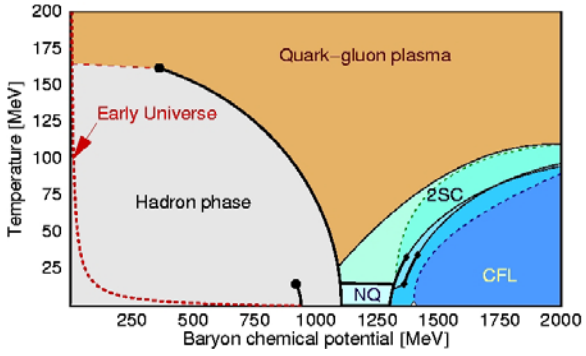

Figure 1: Matter consisting of quarks and gluons and high temperature and/or density may take many forms, some of them quite exotic (perhaps realized in the interior of neutron or quark stars). This figure illustrates a tentative phase diagram.

Oscillations of astrophysical neutrinos
(M. Kachelriess)
The recent discovery that neutrinos oscillate and thus are massive is the fist firm evidence for physics beyond the standard model of physics. Observing neutrinos from cosmic sources offers not only the possibility to learn about astrophysics but also do oscillation experiments with unique baselines and energies. An example is the neutrino signal from a future galactic supernova (SN) that may help to distinguish between some of the currently favored neutrino mixing scenarios. In a series of papers we have identified signatures for these different mixing cases that are independent of astrophysical model uncertainties. The most interesting case studied is the passage of SN shock waves (cf. Fig. 2) through the density region corresponding to resonant neutrino oscillations. The shock waves manifest themselves in a peculiar modulation of the observable neutrino signal that allow one to identify a specific mixing scenario and to perform a neutrino "tomography" of the interior of the SN, cf. Fig.2.

Another example for the potential of astrophysical neutrino sources are galactic beta-beams. The observed excess of high-energy cosmic rays from the Galactic plane in the energy range ~10^{18} eV can be naturally explained by neutron primaries. In this case, neutrons with lower energy decay before reaching the earth and produce a detectable flux of initially pure $_e$-composition in a neutrino telescope like ICECUBE . We have shown that the ratio of the neutrino fluxes arriving on earth depends strongly on the unknown 13-mixing angle $_{13}$ and the leptonic CP phase, opening thus a new experimental avenue to measure these two quantities.

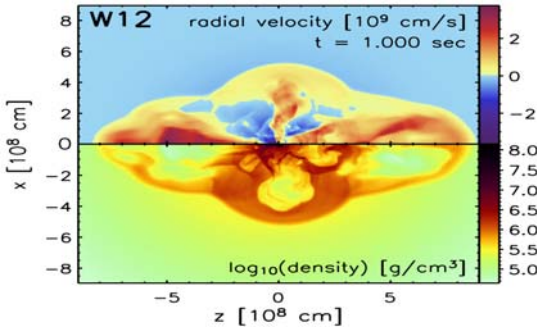

Figure 2:. Radial velocity and density profile at one second after SN shock formation in a 2-dimensional simulation showing a very complex, direction dependent structure.

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* Institute for Energy Technology, Kjeller, (B.Hauback, K.D.Knudsen, A.Skjeltorp, P.G.Helgesen, H.Brinks)
* Centre for Viking and Medieval Studies, University of Oslo
* Department of Chemistry, Biotechnology and Food Science, Norwegian University of Life Sciences (Prof. Vincent G. H. Eijsink)

Local cooperation

* Institutt for konstruksjonsteknikk, NTNU. (I.Brevik og J.B.Aarseth)
* Pedagogisk institutt, og Skolelaboratoriet for matematikk, naturfag og teknologi, NTNU
* Organic Chemistry, NTNU (P.H.Carlsen)
* Plantebiosenteret, NTNU (T.-H. Iversen)
* Department of Process Technology, NTNU (P.V. Hemmingsen and J. Løvland)
* Department of Inorganic Chemistry, NTNU
* Department of Reservoir Technology and Applied Geophysics, NTNU
* Department of Electronics and Telecommunication, NTNU (T. Tybell, B-O Fimland)
* Centre for Biology of Memory, Centre of Excellence, NTNU (E. Moser)
* Department of neuroscience, St. Olav Hospital Norsk Lysteknisk komité
* Department of Biotechnology, NTNU (B.E. Christensen, K.M. Vårum, G.S.B. Bræk, S. Valla, O. Smidsrød, K.I. Draget)
* Institutt for kreftforskning, NTNU: (T. Espevik, A. Sundan)
* Institutt for petroleumsteknologi, NTNU
* Institutt for materialteknologi, NTNU, (K.Marthinsen, M.-A. Einarsrud og T.Grande, O.Lohne)
* Institutt for kjemisk prosessteknologi NTNU (Z. Yu, Chen, A. Holmen)
* Institutt for elektronikk og telekommunikasjon, NTNU (T.Tybell, J.K. Grepstad)
* Institutt for sirkulasjon om bildediagnostikk, NTNU (Christian Brekken og Olav Haraldset)
* NTNU Nanolab
* Numerical Rocks AS, Trondheim (P. E. Øren)
* Optomed (R.Ellingsen, D.R. Hjelme, B. Falch)
* SINTEF (C.Marioara, S.Andersen, J.Walmsley, R. H. Mathiesen)
* SINTEF Energiforskning
* Statoil Research Centre, Trondheim (F. Antonsen, H. Widerøe)
* Tambartun National Resource Center for the Visually Handicapped, Melhus (P.Fosse)
* Trondheim Science Centre

EDUCATION

SUBJECTS AND STUDENT ATTENDANCE

Some subjects were self-study courses in 2005

Subjects		*Student Attendance*
M.Sc. Applied Physics and Mathematics 1st and 2nd year.		
TFY4100	Physics for Product Development and Materials, Industrial Design, Industrial Economics and Technology Management (incl. lab)	201
TFY4105	Physics for Civil and Transport Engineering	172
TFY4110	Physics for Geosciences and Petroleum Engineering (incl. lab)	84
TFY4115	Physics for Electronics Engineering, Engineering Cybernetics (incl. lab)	170
TFY4120	Physics for Chemical Engineering and Biotechnology, Materials Science and Engineering (incl. lab)	126
TFY4125	Physics for Computer Science, Communication Technology	238
TFY4135	Physics for Marine Technology (incl. lab)	73
TFY4145	Mechanical Physics (incl. lab)	123
TFY4155	Electromagnetism (incl. lab)	121
TFY4160	Wave Physics (incl. lab)	106
TFY4165	Thermal Physics (incl. lab)	116
TFY4180	Physics for Energy and Environment (incl. lab)	105
TFY4215	Chemical Physics and Quantum Mechanics	122
M.Sc. Applied Physics and Mathematics 3rd year.		
TFY4170	Physics 2 for Electronics Engineering	58
TFY4175	Material Physics and Characterization (incl. lab)	23
TFY4185	Measurement Techniques (incl. lab)	80
TFY4190	Instrumentation (incl. lab)	82
TFY4195	Optics (incl. lab)	75
TFY4205	Quantum Mechanics	79
TFY4230	Statistical Physics	88
TFY4240	Electromagnetic Theory	66
TFY4250	Atomic and Molecular Physics	76
TFY4260	Cell Biology and Cellular Biophysics (incl. lab)	32
M.Sc. Applied Physics and Mathematics 4th year.		
TFY4200	Optics, Advanced Course (incl. lab)	6
TFY4210	Applied Quantum Mechanics	28
TFY4220	Solid State Physics (incl. lab)	68
TFY4225	Nuclear and Radiation Physics (incl. lab)	75
TFY4235	Computational Physics	12
TFY4245	Solid State Physics, Advanced Course	17
TFY4255	Materials Physics (incl. lab)	8
TFY4270	Theory of Classical Fields	29
TFY4275	Classical Transport Theory	6
TFY4280	Signal Processing (incl. lab)	14
TFY4285	Subatomic Physics	26
TFY4300	Energy and Environmental Physics	31
TFY4305	Non-linear Dynamics	32
TFY4310	Molecular Biophysics (incl. lab)	21
TFY4315	Biophysics (special)	19

TFY4320	Medical Physics (incl. lab)	22
TFY4325	Astrophysics	36
TFY485x	Experts in Team, Interdisciplinary Project	44

M.Sc. Applied Physics and Mathematics 5th year.

TFY4265	Biophysical Micromethods (incl. lab)	12
TFY4700	Biophysics, Specialization	17
TFY4705	Physics, Specialization	28

B.Sc. Physics

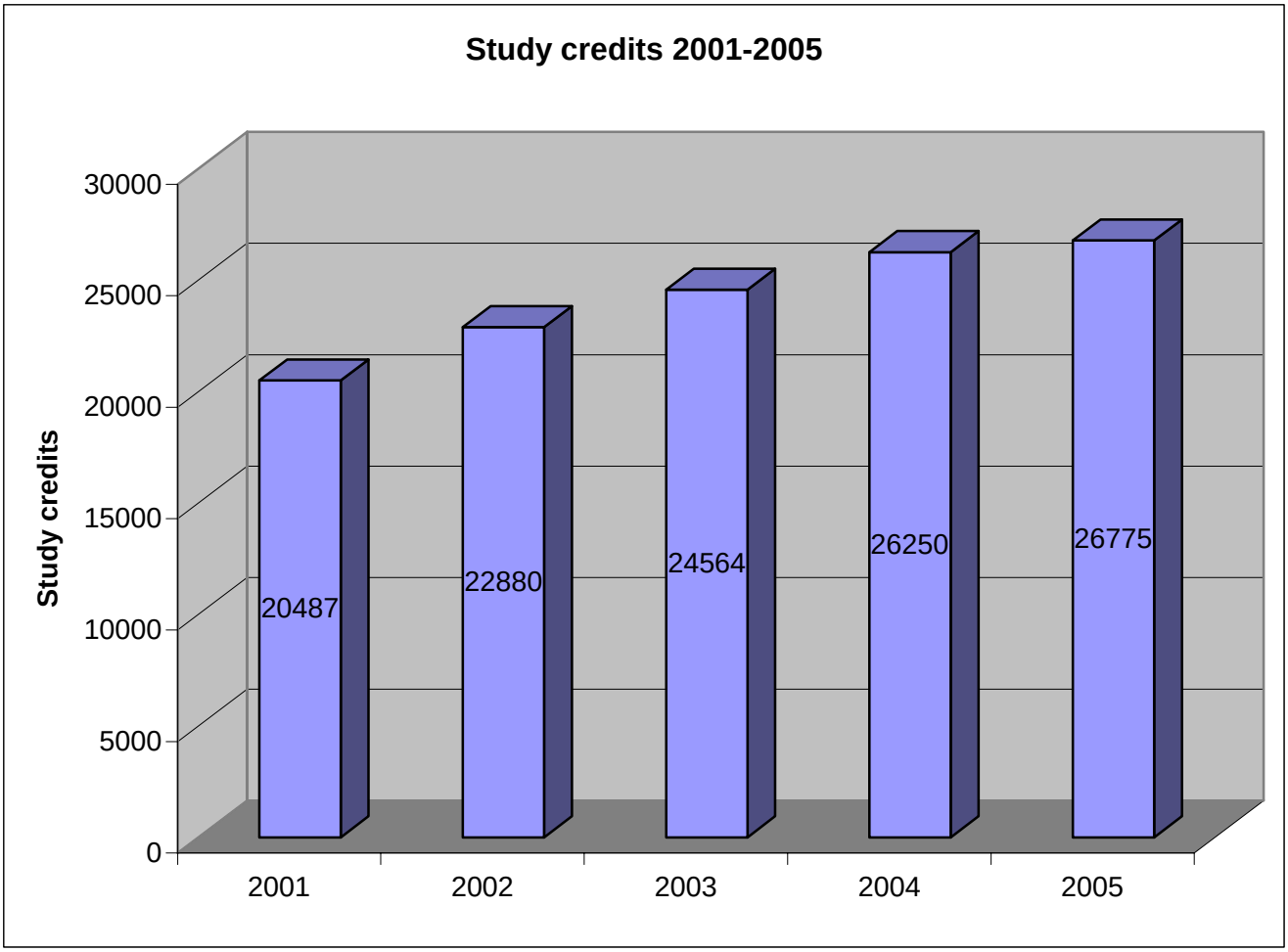
FY0001	Service Course in Physics (incl. lab)	36
FY1001	General Physics I (incl. lab)	105
FY1002	General Physics II (incl. lab)	32
FY1003	Electricity and Magnetism I	58
FY1004	Introduction to Quantum Physics	25
FY1005	Thermal Physics (incl. lab)	22
FY1013	Electricity and Magnetism II (incl. lab)	37
FY2045	Quantum Physics (incl. lab)	13
FY2302	Biophysics I (incl. lab)	9
FY2450	Astrophysics	23
FY3020	Space Technology I	46

M.Sc. Physics

FY2290	Energy Resources	12
FY2800	Physics project	6
FY2900	Didactics in Physics (incl. lab)	3
FY3006	Sensors and Transducers (incl. lab)	6
FY3021	Space Technology II	23
FY3070	Light, Vision, Colour (incl. lab)	7
FY3114	Functional Materials	5
FY3201	Atmospheric Physics (incl. lab)	12
FY3402	Subatomic Physics	2
FY3403	Particle Physics	30
FY3454	Cosmology and Astro-particle Physics	16

PhD Physics / Biophysics

FY8101	Crystallography – Scattering and Diffraction	1
FY8103	Light- and Neutron Spectroscopy	6
FY8104	Application of Symmetry Groups in Physics	6
FY8105	Superconductivity: Physics and Application	6
FY8200	Advanced Statistical Physics	1
FY8201	Nanoparticle and Polymer Physics I	1
FY8203	Soft Condensed Matter	1
FY8204	Nanoparticle and Polymer Physics II	1
FY8300	Quantum Optics	9
FY8301	Mesoscopic Physics	4
FY8302	Quantum Theory of Solids	3
FY8303	Phase Transitions and Critical Phenomena	1
FY8307	Relativistic Quantum Mechanics	10
FY8401	Interactions of Ionizing Radiation with Matter	1
FY8402	Dosimetry of Ionizing Radiation	3


Study credits 2001-2005
Study credits
30000
25000
20000
15000
10000
5000
0
20487
22880
24564
26250
26775
2001
2002
2003
2004
2005

THESES - GRADUATE STUDIES

Master of Science in Applied Physics and Mathematics

Andreassen, Hanne Blytt; *Cross-validation of quantitative whole body autoradiography (QWBA) and gamma scintillation counting for studies of biodistribution of 99 mTc-labelled substances in rats*
Supervisor: Tore Lindmo

Berge, Asbjørn Herland; *Chemical Force Microscopy - Adhesion between functional groups*
Supervisor: Anne Borg

Bergstrøm, Bjarte Aune; *Development and assessment of controls for use in high-throughput studies of alternatively spliced genes*
Supervisor: Bjørn Torger Stokke

Brenn, Marianne Kolstad; *Quantification of choline metabolites in cancer tissue by HR MAS MR-Spectroscopy*
Supervisor: Tore Lindmo

Brøvig, Runar; *Genetic aberrations in cervix cancer detected with microarrays*
Supervisor: Bjørn Torger Stokke

Bråtane, Bernt Tore; *Effect of cerebrospinal fluid from patients with neurological disorders on cultures of cortical neurons*
Supervisor: Tore Lindmo

Børven, Jon-Mattis; *Spectrum and eigenstates of a spin-triplet superconductor coexisting with an XY ferromagnet*
Supervisor: Asle Sudbø

Dalaker, Halvor; *Adsorbates on NiAl(110) - DFT study*
Supervisor: Anne Borg

Eitrheim, Knut Kjærand Frellumstad; *Acquisition of aerosol optical depth. CIMEL CE318 radiometer instrumentation and validation*
Supervisor: Berit Kjeldstad

Eldevik, Simen; *Modeling of formation flying satellites using orbit element description*
Supervisor: Berit Kjeldstad

Emblem, Kyrre Eeg; *Non-invasive measuring of brainperfusion in MRI*
Supervisor: Tore Lindmo

Frafjord, Øyvind; *Methanol adsorption on NiAl(110) and Ni3Al(111) studied by NEXAFS and PES*
Supervisor: Anne Borg

Furuseth, Åsmund; *Multiwalled carbon nanotubes: characterization after production by the arc discharge method*
Supervisor: Randi Holmestad

Garcia, Melina; *Growth of vertically aligned carbon nanofibers*
Supervisor: Turid Worren

Gaudestad, Haakon; *Biaxial preferred orientation in poly (3-hexylthiophene) films studied by X-ray diffraction*
Supervisor: Emil J. Samuelsen

Gaustad, Jon-Vidar: *Blood flow and extracellular volume fraction in human melanoma xenografts measured by dynamic contrast-enhanced magnetic resonance imaging compared with histology*
Supervisor: Einar Rofstad

Glimsdal, Eirik; *Characterization of multi-photon absorption processes in molecules*
Supervisor: Mikael Lindgren

Gunnarsson, Vidar; *TEM/STEM-study of catalyst systems based on carbon nano-fibres, metal oxides and Au nanoparticles*
Supervisor: Bård Tøtdal

Hagen, Aleksander Berning; *UV Radiation on the Ground - by Satellite Information and Ground Based Measurements*
Supervisor: Berit Kjeldstad

Hansen, Snorre; *Ballistic electron transport in NFN structures*
Supervisor: Arne Brataas

Hansen, Torgeir; *Calculations of elastic constants of precipitates in Al-Mg-Si alloys*
Supervisor: Randi Holmestad

Harman, Gunhild; *Studies of radiosensitizing effects of gemcitabine, cytarabine and their ester derivatives in colorectal cancer cell lines*
Supervisor: Tore Lindmo

Hatlo, Marius; *Current-induced magnetization dynamics in a ferromagnetic quantum dot*
Supervisor: Arne Brataas

Henriksen, Lene Hæreid; *Evaluation of energyproduction for the "Wave Screen" concept*
Supervisor: Randi Holmestad

Herikstad, Roger; *Photon Detection i the Human Eye*
Supervisor: Bo-Sture Skagerstam

Hjellset, Bjørn; *Dosimetry in small photon fields for use in intensity modulated radiation therapy: comparisons with fields calculated in radiation treatment planning systems*

Supervisor: Arne Skretting

Hoem, Stian Samset; *Spectral measurements of solar ultraviolet radiation. Instrumentation and calibration*
Supervisor: Berit Kjeldstad

Holtedahl, Jon Erik; *Testing of polymergel as dosimeter in radiotherapy*
Supervisor: Arne Skretting

Hysing, Liv Bolstad; *Verification of IMRT using normoxic polymer gel (THP-gel)*
Supervisor: Tore Lindmo

Johnsen, Jan Roger; *Characterization of prefibrillar amyloidogenic oligomers using fluorescence spectroscopy*
Supervisor: Mikael Lindgren

Jonassen, Marian; *Comparison of two methods of radiation therapy of breast cancer after mastectomy at The University Hospital of North Norway; dosing with tabulated values and 3D treatment planning*
Supervisor: Tore Lindmo

Juul, Helge; *Measurement setup and parameter extraction for 1/f noise characterization of CMOS transistors*
Supervisor: Helge Skullerud

Landmark, Ingrid Dypvik; *Spatial MR relaxometry*
Supervisor: Tore Lindmo

Lie, Espen Oen; *Bayesian NMO inversion and its improvement on AVO analysis*
Supervisor: Alex Hansen

Linder, Jacob Rune; *Use of coherent interactions to influence the neutrino oscillation pattern*
Supervisor: Kåre Olaussen

Lindseth, Inger Marie; *Spatial resolution properties for Elekta iViewGT EPID*
Supervisor: Tore Lindmo

Melhus, Katrine; *Cell death induced by the alfa-emitting radioimmunoconjugate 227Th-rituximab in a Burkitts lymphoma cell line*
Supervisor: Tore Lindmo

Mo, Kristi; *Adsorption on the Ni3Al(111) surface - a DFT stud*
Supervisor: Anne Borg

Mortensen, Lasse-Andre; *Extrapolating of timeseries with the use of wavelets*
Supervisor: Alex Hansen

Naustdal, Rita Terese; *Estimating seismic parameters using long offset seismic data*
Supervisor: Bjørn Torger Stokke

Ng, Sebastian; *Particle production caused by time dependent parameters in Quantum Field Theory*
Supervisor: Kåre Olaussen

Pryde, Linda Skare; *Evalution of RFA techniques with ultrasound guidance and monitoring*
Supervisor: Tore Lindmo

Rodriguez, Mathias Chakib Bellout: *Sensitivity of Normal and Dichromatic Subjects to Cone-isolating Stimuli. Measured by Visually Evoked Potentials and Psychophysics*
Supervisor: Arne Valberg

Rystad, Nils Vidar; *STM nanostructuring of SrRuO3*
Supervisor: Anne Borg

Samuelsen, Bjørn Tore; *Photo emission studies of nanostructurated surfaces*
Supervisor: Steinar Raaen

Skadsem, Hans Joakim; *Current-induced magnetization dynamics in a ferromagnetic quantum dot*
Supervisor: Arne Brataas

Skriudalen, Stian; *Photon Detection in the Human Eye*
Supervisor: Bo-Sture Skagerstam

Steindal, Arnfinn Engeset; *Photobiophysical and spectroscopical investigations on 5-metyl tetrahydrofolate in aqueous solution and in human blood*
Supervisor: Anders Johnsson

Stene, Tore; *HRTEM-studies of precipitates in AlMgSi(Cu)-alloys*
Supervisor: Randi Holmestad

Strandberg, Rune; *QSSPC measurements of minority carrier lifetime and determination of iron consentration in solar cell silicon*
Supervisor: Turid Worren

Størdal, Ingunn; *Transfection of the cancer cell line OHS with DsRed2 in order to distinguish cancer tissue from normal tissue in dorsal window chamber on mice studied by confocal and multiphoton laser scanning microscopy*
Supervisor: Tore Lindmo

Sunde, Bjørn Magnus: *ELF Electromagnetic Communication in Pipelines*
Supervisor: Helge Skullerud

Suphellen, Aina; *Amorphous silicon as surface passivation of solar cell silicon*
Supervisor: Turid Worren

Sæten, Christina; *Optimization of Transfected Cell Arrays (TCA) for use in high throughput hypothesis testing of gene function*
Supervisor: Tore Lindmo

Teigen, Sigurd Henrik; *Efficient calculation of stratified flow over complex topography*
Supervisor: Johan Skule Høye

Thiis-Evensen, Einar; *Comparative studies of degree of order of stereo-regular and non-stereo-regular polymeric semiconductor poly-octyl-thiophene (POT)*
Supervisor: Emil J. Samuelsen

Thomassen, Sedsel Fretheim; *Simulation of diffractive optical elements*
Supervisor: Mikael Lindgren

Thorshaug, Steinar; *Static small angle light scattering in measuring particlesizes*
Supervisor: Jon Otto Fossum

Tronstad, Christian; *Portable instrument of measuring sweat activity. Theory, development and construction*
Supervisor: Tore Lindmo

Van Wingerden, Mattheus Theodorus Johannes; *Compaction of DNA employing polycations: Characterization with fluorescence spectroscopy*
Supervisor: Gjertrud Maurstad, Bjørn Torger Stokke and Mikael Lindgren

Vea, Jan Sverre Brander; *Ohmic contacts for GaAs solar cells*
Supervisor: Turid Worren

Wennberg, Lena Cecilie; *Sample preparation with tripod for characterising of SRO thin films in TEM*
Supervisor: Randi Holmestad

Aarbogh, Harald; *Ballistic electron transport in NFN structures*
Supervisor: Arne Brataas

Cand. Scient. in Physics:

Berner, Ingeborg:
Supersymmetrisk bidrag til myonets anomale magnetiske moment
Supervisor: Kjell Mork and Terje Meisler

Bjørkli, Knut:
Video for web i undervisningen av fysikk – økt læringseffekt?
Supervisor: Berit Kjeldstad

Evensen, Anders Kjeldrud:
Models of Decoherence in Quantum Physics
Supervisor: Bo-Sture Skagerstam

Master of Science in Physics

Kulhawczuk, Martin:
Fotoinduserte reaksjoner i Propionibacterium areas. Biofysiske studier av porfyringsproduksjon, toksisitet og PDT-effekt etter behandling med ALA og metyl-ALA
Supervisor: Anders Johnsson

Mejdell, Astrid Lervik:
Thickness dependent behaviour of palladium-Silver membrans
Supervisor: Anne Borg

Drani, Edward Nyeinga:
A new parameter suitable for modelling of solar beam radiation
Supervisor: Jørgen Løvseth

Ireeta, Tumps Winston:
Deformation measurements with modern electro-optics and software
Supervisor: Helge Redvald Skullerud

Okello, Denis:
Concentrating solar energy systems for high temperature heat production and its potential in Uganda
Supervisor: Jørgen Løvseth

Robinson, Adam James Skogrand:
Scanning probe structure determination of designers polymers derived from DNA
Supervisor: Bjørn Torger Stokke

Shah, Rakesh Kumar:
Aerosol Optical Depth in Nepal and Trondheim Instrumentation and resultants.
Supervisor: Berit Kjeldstad

THESES - DOCTORAL STUDIES

Bergsjordet, Bjørn Åge:
Some Aspects of Cavity Quantum Electrodynamics.
Supervisor: Bo-Sture Skagerstam

Bjarte-Larsson, Torkel:
An investigation of phase-controlled wave-energy converters using vertically floats or buoys to pump water
Supervisor: Johannes Falnes

Fosse, Per:
Psychophysics of Reading and Illumination Needs during Reading in Visually Impaired Subjects with Age-Related Macular Degeneration
Supervisor: Arne Valberg

Smiseth, Jo:
Criticality and novel quantum liquid phases in Ginzburg-Landau theories with compact and non-compact gauge fields
Supervisor: Asle Sudbø

Rudvin, Inger:
Putative magnocellular and parvocellular contributions to the visual evoked potential
Supervisor: Arne Valberg

Smørgrav, Eivind:
Critical properties of effective gauge theories for novel quantum fluids
Supervisor: Asle Sudbø

Støren, Trude:
Functional Imaging in Optical Coherence Tomography
Supervisor: Tore Lindmo

Sund, Torbjørn:
Development and testing of methods for adaptive image processing in odontology and medicine
Supervisor: Arne Skretting

Sæther, Oddbjørn:
NMR spectroscopy applied to the eye: Drugs and metabolic studiese
Supervisor: Anna Midelfart

Vullum, Per Erik:
Ferroelastic LaCoO -based Polycrystalline Ceramics. A Transmission Electron Microscopy and X-ray Diffraction Study
Supervisor: Randi Holmestad

PARTICIPATION IN EVALUATION COMMITTEES

Evaluation committee work

Borg, A.:
* Evaluation committee for professor competence of 1 candidate in Physics, Linköping University
* Member of the evaluation group on ”Condensed matter physics in Sweden”, The Swedish Research Council, Sweden.

Fossheim, K.:
* Chairman of the PhD Evaluation Committee for Torkel Bjarte Larsen
* Chairman of the PhD Evaluation Committee for Per Erik Vullum
* Chairman of the PhD Evaluation Committee for Jo Smiseth
* Chairman of the PhD Evaluation Committee for Eivind Smørgrav
* Committee member for the evaluation of two physics positions at the PGP Center, University of Oslo

Hansen, A.:
* Member of evaluation committee for professor promotion at Department of Physics and Technology, University of Bergen

Kjeldstad, B.:
* Opponent for Jørgen Brustugun, Department of Pharmacy, University of Oslo.
* Member of the evaluation committee for PhD Evelyn Jäkel, Department of Physics and Geosciences, University of Leipzig, Germany

Samuelsen, E. J.:
* Evaluation of four candidates for extra-ordinary research support by the Research Council of National Sciences and Engeneering, Academy of Finland, Helsinki

Arrangements

Elgsæter, A.:
* Convenor of "Fredagskollokviet i fysikk"

Hansen, A.:
* Organizer of "Complex Systems under the Midnight Sun", Tromsø 27-30 June 2005 (Nordita Workshop)

Hunderi, O.:
* Member of the organising committee of "Optics of Surfaces and Interfaces (OSI-6)", Aalborg, 6-10 June 2005
* Member of the organising committee of EMRS 2005, Strasbourg, 2005
* Member of the organising committee of "Nanomat-Birkelandskonferansen", Trondheim, 2005
* Member of the organising committee of EPIOPTICS 7", Erice, Sicilia, 2006

Sudbø, A.:
* Convenor of "Fredagskollokviet i fysikk"

PARTICIPATION IN NATIONAL, INTERNATIONAL, UNIVERSITY AND DEPARTMENTAL COMMITTEES

International commissions

Borg, A.:
* Member of "Beredningsgrupp för kondenserade materiens fysik", The Swedish Research Council, Sweden.
* Member of the IUPAP (International Union of Pure and Applied Physics) Working Group on Women in Physics.

Fossheim, K.:
* Vice President of The Royal Norwegian Society of Sciences and Letters, Trondheim
* Chairman of the Jury for the award of Dr. A. De Leeuw-Damry-Boulart Prize for Exact Sciences, awarded once every 5 years by the Flemish Science Foundation, Belgium
* Member of the NTNU Contact Committee for CAS, Center of Advanced Study, Oslo

Hansen, A.:
* Secretary to the Board of European Physical Society's Computational Physics group.
* Member of the prize committee for European Physical Society's Berni Alder Prize in Computational Physics.
* Member of the International Union of Pure and Applied Physics (IUPAP), Commission of Statistical Physics (C3).

Hunderi, O.:
* Editorial board for scientific journals. Editorial Board, New Journal of Physics 2002-

Kjeldstad, B.:
* Member of World Meteorological Organisation, Scientific advisory Group for Ultraviolet Radiation measurements (WMO UVSAG)

Mo, F.:
* Associate editor - Crystallography Review (Taylor & Francis)
* Member of the Proposal Review Committee at SLS (Swiss Light Source), Villigen, Switzerland.

Samuelsen, E. J.:
* Norwegian representative in the Council of the European Synchrotron Radiation Facility ESRF, Grenoble
* Member of Nordsync, Nordic Consortium for Synchroton Radiation (Denmark, Finland, Norway, Sweden)
* Nordic member in "ESRF Working Group on *Balance of Use and Payment*"

National comissions

Borg, A.:
* President, Norwegian Physical Society
* Member of the "National Committee on World Year of Physics 2005"
* Member of the steering committee of the ESF Scientific Program "Nanotribology (NATRIBO)".
*Member of "Ressursfordelingskomitéen for tungregning", Norwegian Research Council.
* Member of the board of NTVA.

Fossum, J. O.:
* Leader of Condensed Matter with Atomic Physics Division of Norwegian Physical Society

Hunderi, O.:
* Member of the "National committee on World Year of Physics 2005"

Kjeldstad, B.:
* Member, Board of University of Svalbard (from September)
* Education committee for geophysical courses at University of Svalbard
* Substitute member, Board of Sør-Trøndelag University College, Faculty of Technology

Mo, F.:
* Member of the Committee for Synchrotron Research, Norsk Synkrotronforskning AS

Stokke, B. T.:
* Chairman of the board of NANOMAT programme at the Research Council of Norway

University and Departmental commissions

Borg, A.:
* Vice dean on education, Faculty of Natural Sciences and Technology, from November 2005.
* Member of FUS ("Forvaltningsutvalget for sivilingeniørutdanningen") at NTNU.

Fossum, J. O.:
* Chairman of Division of Complex Materials (until July)

Hansen, A.:
* Deputy Head of the Department of Physics, NTNU (until August 1st)

Hunderi, O.:
* Chairman, "Studieprogramråd" for fysikk og matematikk
* Chairman, Detail Planning Committee for the physical cleaning room, NTNU Nanolab
* Member, Ledergruppen NTNU Nanolab
* Chairman of Division of Condensed Matter Physics (from August)

Johnsson, A.:
* Head of Department of Physics, NTNU (until August 1st)
* Member, Board of the Faculty of Natural Science and Technology
* Steering Committee "Kunnskapsforlaget"
* Member of "Norsk Fysikkråd"

Kjeldstad, B.:
* Member, Board of Department of Physics,
* Substitute member, Board of the Faculty of Natural Science and Technology
* Chairman of Division of Applied Physics and Didactic Physics

Lindmo, T.:
* Manager Strategic University Programme in Medical Technology
* Deputy Director Strategic Area of Medical Technology at NTNU
* External member of the Board, Department of Mathematical Sciences
* External member of the Board, Department of Cancer Research and Molecular Medicine
* Chairman of Division of Biophysics and Medical technology

Mikkelsen, A.:
* Chairman of Division of Complex Materials (from July)

Olaussen, K.:
* Chairman of the Division of Theoretical Physics (until July)
* Deputy Head of the Department of Physics (from August)

Samuelsen, E. J.:
*Chairman of the Division of Condensed Matter Physics (until July)

Skullerud, H.R.:
* Member, Board of the Faculty of Natural Science and Technology

Stokke, B.:
* Vice Dean at Faculty of Science and Technology (until August 1st)
* Head of Department of Physics (from August 1st)
* Chairman of faculty education committee (until August 1st)
* Chairman of the board, NTNU NanoLab
* Member, board of committee for Medical Technology at NTNU
* Project Director, Thematic Area Materials at NTNU (until November 1st)

Sudbø, A.:
* Chairman of the Division of Theoretical Physics (from August)

Worren, T.:
* Member leader group "Senter for fornybar energi"
* Member, board of the "Geminisenter PV solcellematerialer"

FRIDAY AFTERNOON LECTURES

"Fredagskollokviet i fysikk"

Convenors: Arnljot Elgsæter and Asle Sudbø

Programme – spring term

04.02 Jahnavi Phalkey (Georgia Institute of Technology, Atlanta): *History of Scientific Instruments and Practices in India: A study of selected particle accelerator facilities (1938-1966)*

11.02 Einar Aas (NTNU):
Moores lov i 40 år. Hvor lenge vil den fortsatt gjelde?

18.02 Eivind Smørgrav (NTNU):
Vortex sub-lattice melting in a two-component superconductor

25.02 Harald Øye (NTNU)
Aluminum electrolysis. Principles, environmental concerns and new technology

04.03 Bjørn Gjevik (UiO): *Large destructive waves from earthquakes and slides*

11.03 Joachim Mathiesen (NTNU):
Laws of 2-dimensional crack growth

18.03 Hans Blom (Göttingen):
The Nanoscope, future in imaging and spectroscopy

01.04 Ralf Metzler (NORDITA):
Coupled dynamics of local DNA denaturation zones and selectively single stranded DNA-binding proteins

08.04 Finn Ravndal (UiO):
Gravitation, extra dimensions and the cosmological constant

15.04 Daniel Huertas-Hernando (NTNU):
Nanotechnology with Quantum Dots

22.04 Pekka Suortti (Univ. i Helsinki):
Medical imaging and therapy with synchrotron radiation

29.04 Arne Skjeltorp (IFE):
Properties and application of nanocarbon

20.05 Tom Henning Johannsen (UiO):
Magneto-optical imaging of vortices and flux avalanches in superconductors

27.05 Vadim Geshkenbein (ETH, Zürich):
Quantum computing

03.06 Erik Aurell (KTH):
Many hard combinatorial optimization problems are easy

Programme - autumn term

02.09 Professor Kristian Fossheim, Institutt for fysikk, NTNU: *Ivar Giæver*

09.09 Professor Joe Trodahl, Victoria University, Wellington, New Zealand: *Heat flow in sea ice and its influence on the climate*

16.09 Professor Anders Johnsson, Institutt for fysikk, NTNU, Dr. Ragnvald Mathiesen, SINTEF Materialer og kjemi, professor Tor Henning Iversen, Institutt for biologi, Plantebiosenteret, NTNU, og Bjarte Solheim, Institutt for fysikk, NTNU: *Mikrogravitasjon*

23.09 Professor Helge Nørstrud, Institutt for energi-og prosessteknikk, NTNU: *Simuleringer av Columbiaulykken*

30.09 Eivind Smørgrav, Institutt for fysikk, NTNU: *Observation of a ohmic superfluid in a large-scale numerical experiment.*

07.10 Professor Gerrit E.W. Bauer, Delft University of Technology: *Mesmerizing semiconductors: current-induced spins in the two-dimensional electron gas*

14.10 Professor Eivind Hiis Hauge, Institutt for fysikk, NTNU: *Lars Onsager, the NTH-student who went on to win the Nobel Prize*

21.10 Forsker Knut Jørgen Røed Ødegård, Astrofysisk institutt, UiO: *Bang! Universets mest ekstreme stjerner og andre kosmiske katastrofer*

28.10, Professor Bjørn Jamtveit, Physics of Geological Processes, UiO: *Fracturing-assisted reactive transport*

04.11 Professor Zlatko Tesanovic, Johns Hopkins University: *Music of the (fermi) spheres: Gauge theories of quantum matter.*

11.11 Professor Jens Oluf Andersen, Institutt for fysikk, NTNU: *Bose-Einstein condensation*

25.11 Dr. Williams Lefebvre, Groupe de Physique des Matériaux, Universite de Rouen: *Phase separation in several alloys as investigated by 3D Atom Probe*

02.12 Professor Jan Swensson, Institutt for fysikk, NTNU, Helén Jansson and Rikard Bergman, Department of Applied Physics, Chalmers University of Technology, Göteborg, Sweden: *Glass transition and relaxation processes of supercooled water in biological and model systems*