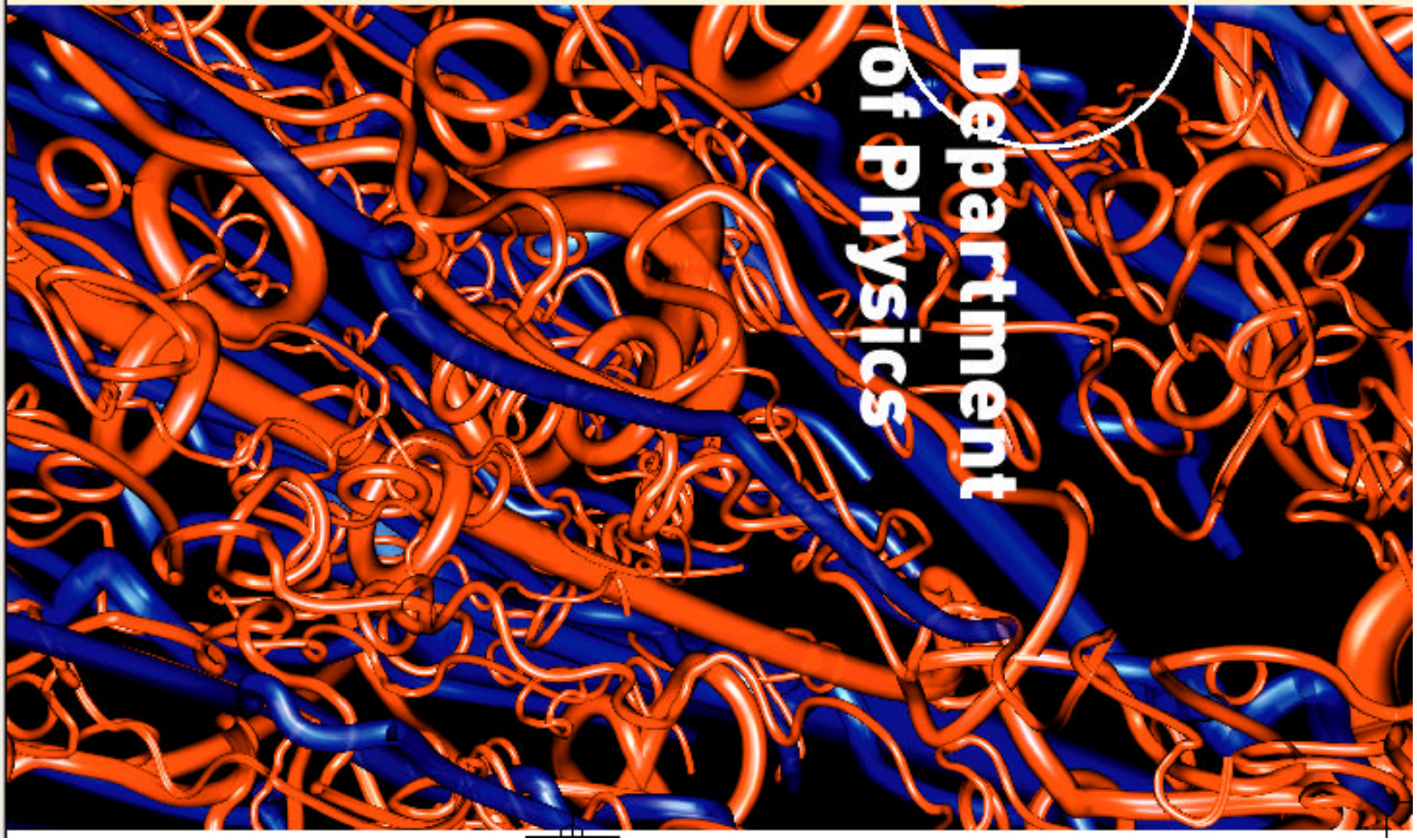
Annual Report 2004



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 Simen Ellingsen (until Sept.) Student Sigmund M. Hope (from Sept.) Student Torgar Haugen
Appointed external member:	
From Electromagnetic Geoservice	Managing Director Terje Eidesmo

COVER PAGE
Quantum tornadoes in the ultimate light metal.
The picture shows a snapshot of vortex systems due to protonic superconductivity (red tornadoes) and electronic superconductivity (blue tornadoes), as obtained from large-scale Monte Carlo-simulations (Courtesy Jo Smiseth).

DEPARTMENT OF PHYSICS, NTNU

www.phys.ntnu.no

CONTENTS

Edited by:

Sylvi Vefsnmo, Anders Johnsson, Emil J. Samuelsen, Margit C. Hagen, Arne Mikkelsen

The Annual report is also available on the internet address:

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

Synopsis of events in 2004.

The Department of Physics at the Norwegian University of Science and Technology has traditionally had three main tasks: to provide high quality education to undergraduate and graduate students; to conduct research in physics at a high international level; and to disseminate popularized information on topics related to physics.

Recently the University asked its staff to go into activities promoting industrialization and trade and industry directed activities. This has long been part of the staff activities at the Department of Physics, realized e.g. by the close cooperation in some sectors with the SINTEF foundation. Strong cooperation has led to achievements within the fields of material physics and technology, within optics and within the oil and gas sector. The new approach by the University to broaden the contact with the applied sector has resulted in a newly established Technology Transfer Organization (TTO). Representatives have discussed with the staff on possible projects, and some very interesting possibilities have been identified.

In the year 2004 a new associated professor in Energy and Environmental physics was appointed and started the work at the Department. Two new fulltime professors in Condensed Matter Physics were appointed and were to start their duties in the beginning of year 2005.

The ”Quality Reform” in the teaching sector of the Universities in Norway was going into a more stable form during 2004. The overall focus is on more intensive teaching and contact with the students. The teaching in the physics laboratory courses has always been strongly focussed on the learning of each individual student. The reform, therefore, implies more changes in the classroom teaching and the examination procedures. The implementation of the reform will be evaluated during 2005.

Much work was focussed on the planning for activities related to the “World Year of Physics 2005”. Preparation for conferences, public seminar series, school visits etc. was carried out. It was decided to follow up the large number of school contacts and school visits that belongs to the everyday life of the Department.

At this introductory place the reader should be reminded about the fact that the year was characterized also by the steady production of scientific publications, master theses, doctoral theses and conference attended. In the present days, characterized by continuous changes and reorganizations, the central core of the activities - the research and the teaching - has to be cared for.

The staff has been engaged in a number of external activities, committee work, activities to promote physics in a broad context. This report wants to give a short presentation also of those diverse activities.

The mechanical workshop was administratively transferred to our Faculty by January 2004. The Department would like to express its thankfulness to the workshop and its leader, Arnolf Bjølstad, for excellent craftsmanship throughout the years when it was organized under the Department of Physics.

The external funding of projects at the department has increased during 2004 as compared with 2003. This is satisfactory since it is foreseen that in the future a larger part of the activities must be externally financed.

The Department of Physics is involved in research areas that the Norwegian Parliament, the Norwegian Research Council and/or the University have appointed as focussed research fields with high priority. This annual report mentions a few of involvements– it would be impossible to present all of them. Enough to say that the Department has special interest in areas like medical technology, material sciences, nanotechnology - nanomaterials. Again external research support contributes substantially to the activities of the Department, also in these areas of research.

April 2005

Anders Johnsson
Head of Department

STAFF

Head of Department:
Professor Anders Johnsson

Deputy Head of Department:
Professor Alex Hansen

Permanent staff

Scientific staff:

Professors
Anne Borg, Arne Brataas, Catharina Davies, Arnljot Elgsæter, Kristian Fossheim, Jon Otto Fossum, Alex Hansen, Eivind Hiis Hauge (University Rector), Randi Holmestad, Ola Hunderi, Johan S. Høye, Anders Johnsson, 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, Hans Magne Pedersen (deceased), Steinar Raaen, Emil J. Samuelsen, Bo-Sture Skagerstam, Helge R. Skullerud, Bjørn Torger Stokke, Asle Sudbø, Arne Valberg.

Associate professors
Per Morten Kind, Tore H. Løvaas, Thorarinn Stefansson, Knut Arne Strand, Jon A. Støvneng, Bård Tøtdal, Sigmund Waldenstrøm, Turid Worren, Ingjald Øverbø.

Adjunct professors
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, Jan S. Mastad, Arne Moholdt, Jon Ramlo, Kåre O. Rokhaug, Inge Sandaunet, Bertil O. Staven, Kristin Grendstad Sæterbø.

*Mechanical workshop has been transferred to the Faculty

Temporary staff:

Post doc.
Trine Højberg Andersen, Egor Babaev, Ahmed Gmira, Antonius van Helvoort, Morten Kildemo, Yves Meheust, Stine Nalum Næss, Sverre Vegard Pettersen, Ståle Ramstad, Albert Reiner, Nils Sandberg, Pradhan Srutarshi, Ingunn Tufto, Roland Wittje, Jonas Ørtegren.

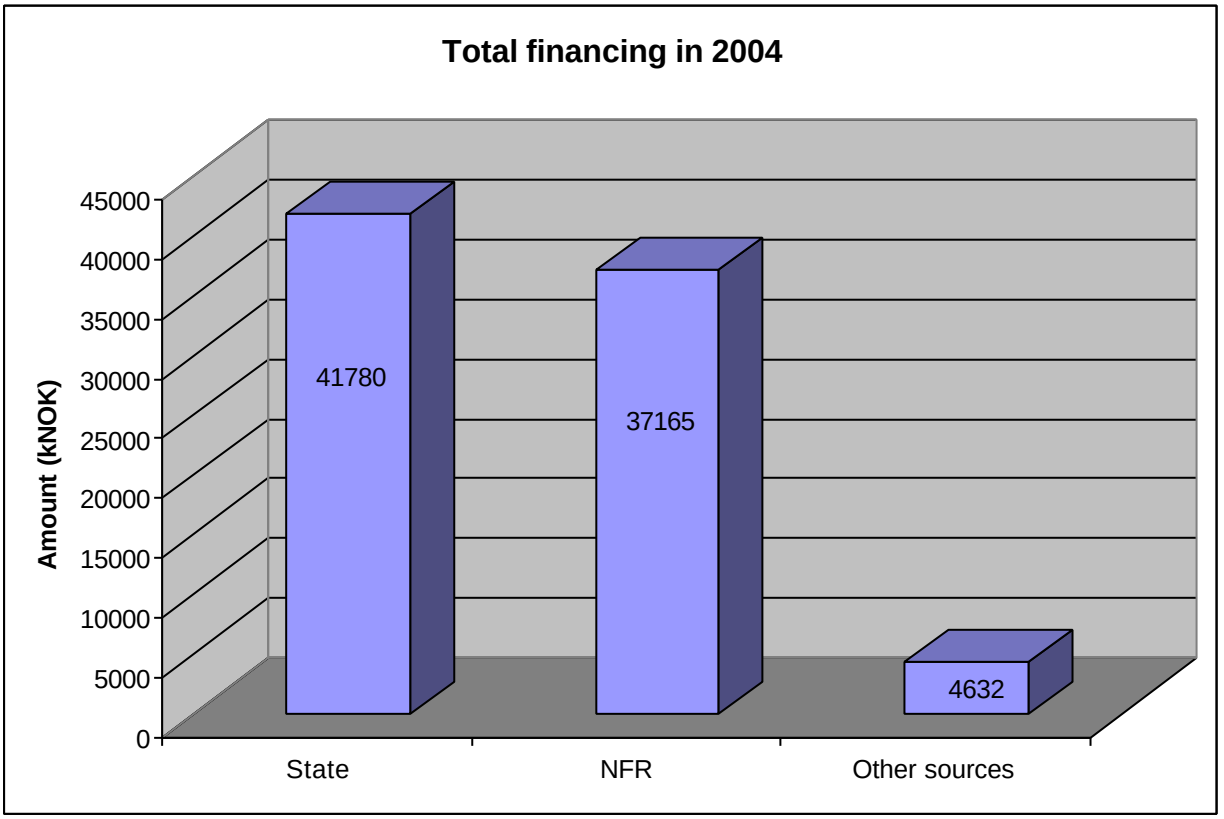
Senior staff
Johannes Falnes, Per C. Hemmer, Knut Lønvik, Jørgen Løvseth, Kjell Mork, Reidar Nydal (deceased), Haakon Olsen, R. Svein Sigmond, Ivar Svare.

Doctoral students
Carmen Andrei, 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, Lars Løseth, Devi Dhavraj Meena, Samsun Mohamad, Jan Petter Morten, Heidi Nordmark, Kanak Parmar, Amutha Ramachandran, Thomas Ramstad, Ole Christen Reistad, Inger Rudvin, Terje Røsten, Stein Olav Skrøvsth, Roman Shcheluskin, 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, Ulrik Thisted, Sven Tierney, Wakshum M. Tucho, Per Erik Vullum, Lars Erik Walle.

TOTAL FINANCING IN 2004

Description of project financed or name of contributor	Recipient	Amount KNOK
Financial contribution from the Government University budget		**41 780**
Contributions from the Norwegian Reasearch Council NFR		
Nanostructured Soft and Complex Materials	Alex Hansen	4 000
Cooperation and exchange with France	Alex Hansen	100
Dr. ing.student	Alex Hansen	498
Two-Phase Flow	Alex Hansen	555
Petromax	Alex Hansen	100
Electromagnetic fields and biological effects	Anders Johnsson	695
Structural, electronic and optical properties of overlayers on surfaces	Anne Borg	635
FUNMAT	Anne Borg	367
FUNMAT, PhD student	Anne Borg	635
Fysikkåret 2005	Anne Borg	280
Quantum Transport in Nanoscale Systems	Arne Brataas	160
Transport or spin and charge in semiconductors	Arne Brataas	555
Quantum Transport in Nanoscale Systems	Asle Sudbø	605
Multikomponent Superconductivity	Asle Sudbø	654
IKT-oxides	Asle Sudbø	13 380
Factors controlling UV radiation in Norway	Berit Kjeldstad	560
Material fluxes from the Russian Rivers Ob and Yenisey	Berit Kjeldstad	100
Mesoscale structures	Bjørn T. Stokke	555
Polymer gel signal transducers	Bjørn T. Stokke	50
Centre for Biopolymer Engineering at NTNU	Bjørn T. Stokke	187
Intravital nicroscopy and MRI	Catharina Davies	50
Travel support SNBL/ESRF	Frode Mo	306
Experimental investigations	Jon Otto Fossum	635
Post doc. appointment for Yves Méheust	Jon Otto Fossum	369
Atomic Force Microscope	Jon Otto Fossum	500
Structure and Dynamics of Soft and Complex Nanomaterials	Jon Otto Fossum	518
SUP Complex	Jon Otto Fossum	1 000
Dendritic nanoporous materials with multifunctionality	Mikael Lindgren	1 000
Research collaboration Norway - Germany	Mikael Lindgren	40
Light Metal Surface Science	Ola Hunderi	369
Hydrogen storage in metal hybrids	Randi Holmestad	182
Micro- and nanostructure, materials development	Randi Holmestad	3 700
FUNMAT, Stipendiat	Randi Holmestad	635
Heat treatment fundamentals	Randi Holmestad	2 500
Thin-film III-V semiconductors	Turid Worren	690
	Sum	**37 165**

	Recipient	Amount KNOK
Contribution from other financial sources		
Statoil	Alex Hansen	500
VISTA	Alex Hansen	62
Photocure ASA	Anders Johnsson	435
Læringssenteret	Per Morten Kind	263
Linkøping University (BioNanoLab)	Mikael Lindgren	287
FOI, Totalforsvarets foskningsinstitutt	Mikael Lindgren	400
Medical tecnology	Tore Lindmo	49
NUFU	Jørgen Løvseth	1 020
Hydro	Randi Holmestad	1 250
Elkem	Randi Holmestad	250
Statens Strålevern	Tor Wøhni/ Berit Kjeldstad	116
	Sum	**4 632**
Total external financing in 2004		**41 442**



AWARDS

Professor *Hans Kolbenstvedt* was awarded a prize for outstanding pedagogic activities. The NTNU students appointed Hans Kolbenstvedt for this prize, awarded by the Faculty of Science and Technology. Our colleague has for many years lectured in an outstanding way both for the science students and for the technology students in physics and at different levels of our curricula. Many students have continuously attended his humorous, interesting and thoughtful lectures.
We congratulate Hans with this award!

Our previous doctoral student *Anders Frøseth* received in 2004 the ESSO-award for the best theoretical dr.ing. thesis in the year 2003. The title of the thesis is: "Atomistic modelling of the Al-Mg-Si alloy system".

Department of Physics and contributions to strategic research fields.

The Department is engaged in several research fields which have been appointed a special status on national or NTNU level. Those strategic fields coincide partly with the strategic goals of the Department and this important connection should be made visible both for internal and for external purposes. That is why we present some such fields in which the Department has been engaged.

Medical Technology. Research at the Department of Physics contributing to the Strategic Area of Medical Technology at NTNU are found within biomedical optics (optical coherence tomography), transport processes in biological tissue, biopolymer and other biomaterials relevant for therapy, biological effects of electromagnetic fields, as well as within the neuroscience of vision. There are co-operative projects in medical physics with researchers at St.Olav's Hospital related to radiation therapy of cancer and various medical imaging techniques, especially magnetic resonance. The Physics Department gives specialised courses in biophysics and medical technology, and thus serves as one of Norway's most important providers of medical physicists for the health care sector.

The Faculty of Natural Sciences and Technology through the Department of Physics awarded three of the 19 Ph.D. degrees within medical technology at NTNU in the year 2004. One of the professors at the Department of Physics is the Deputy Director of the Strategic Area of Medical Technology at NTNU.

Energy and environment. Energy and environmental groups have activities closely related to the strategic area Energy and Petroleum - Resources and Environment. Research was carried out in wind energy, solar energy where emphasis were put on the potential for use of solar energy in third world countries mainly Africa. A new activity was established within solar cells. Studies of interfaces between different hydrocarbone phases was carried out, with the object of enhanced oil and gas recovery. In addition environmental issues related to use of energy was studied by looking at the effect of aerosols on radiative transfer in the atmosphere, with emphasis on ultraviolet radiation.

ESA, European Space Agency. In a joint effort with the Plant Biocenter, Department of Biology, the Department of Physics participates in activities related to European Space Agency. The NTNU engagement concerns a joint experiment onboard the International Space Station, but also the building of a space communication centre located at NTNU. This centre, a USOC (User Support and Operation Centre), will be a training centre and a communication centre for on-line information exchange between ground and the Space Station. It will be used by European research groups having experiments onboard the Station. This European Centre is now under construction at the Plant Biocenter.

ESRF, European Synchrotron Facility. Members of the Department staff have been strongly involved in the use of the installations at the ESRF, Grenoble all since the opening in 1994. There are two routes of involvement:

- Access to all the 47 beam lines through the national Norwegian membership, channelled through the consortium Nordsync (DK, FIN, NO, SE). The very first Norwegian beam user group was from our Department. The Norwegian representative in the ESRF council since 2000 is a member of our staff.
- Access to the Swiss-Norwegian Beam Lines (SNBL). This collaboration features two independent experiment stations and is operated jointly by CH and N, since 2002 with equal shares. The main initiator of the SNBL, and for many years member of the steering committee, since 1997 observer, is a member of our staff.

The travel expenses and use of the public ESRF beam lines are covered by the ESRF. Travels and subsistence for experiments at

SNBL are paid mainly by the Norwegian Research Council.

During the last years five members of our permanent staff, three members of the SINTEF Physics staff and several post-docs and doctorands have been users of the Grenoble beam lines. Some projects: imaging of solidification fronts in alloys; self-organisation of thin layers of semiconducting polymers; mapping of ferroelectrics under high pressure; metal dusting; radiation influence on a phase transition; aspects of polymer behaviour; clay suspensions.

MAXLAB, Lund. For several years members of our staff have utilized the MAX-lab synchrotron radiation facility at Lund University, Sweden, for photoelectron spectroscopy studies of electronic structure, and interactions at surfaces and interfaces. The access to the beam lines is free, whereas travels and subsistances are covered by the European Commission Human Potential Programme "Access to Research Infrastructures" and NTNU. Examples of projects: overlayers on refractory metal surfaces; rare earth systems; molecular adsorption on catalytically active metal surfaces.

NTNU Nanolab. NTNU Nanolab is an interfaculty initiative within nanotechnology with emphasis on establishing a common shared infrastructure facility and co-ordinate nanotechnology activities at the university. The Department of Physics contributes to the nanotechnology activities within spintronics, characterisation and modelling of nanostructured materials properties. The prestigious young investigator award recipient at the Dept. of Physics, prof. Arne Brataas, is an important contribution to the nanotechnology activity at NTNU. Several research groups at the Department have activities within different aspects of nanosciences. Staff members are involved in various working groups for the future Nanolab strategy, as well as detailed planning of the shared infrastructure facility. One of the professors at the Dept. of Physics is Chairman of the Board of NTNU Nanolab.

Strategic Area of Materials.
Strategic Area Materials focuses on research within light metals, functional materials, polymers and composites and structural integrity. Research within condensed matter physics at the Department of Physics represents significant contributions to various parts of these focus areas. Contributions span from advanced characterisation using. Electron and scanning probe microscopy of nanostructured materials, catalytic surfaces, and functional materials to modelling of material properties. Further information is available from http://www.ntnu.no/materialer-/index.htm. A member of the Department staff serves as the managing director of the Strategic Area Materials Technology - project.

FUGE, Functional Genomics. Functional genomics (FUGE) is a recent national research initiative. Our department contributes to research within this field with physical characterisation of biological macromolecules produced using gene-modified organisms (functional characterisation down to the single-molecule level), and being an active partner within the Molecular Imaging platform at the faculty of Natural Sciences and Technology. The latter part includes effective use of a shared facility for advanced scientific imaging instruments necessary for functional genomics studies.

RESEARCH

DIVISION OF APPLIED PHYSICS AND DIDACTIC PHYSICS

Staff
Professor Berit Kjeldstad
Professor Mikael Lindgren
Professor Ole J. Løkberg
Professor Hans M. Pedersen (Deceased Nov.)
Professor Helge R. Skullerud
Ass. Professor Per Morten Kind
Ass. professor Jørgen Løvseth (Until Nov.)
Ass. professor Tore Løvaas
Ass. professor Thorarinn Stefansson
Ass. professor Knut Arne Strand
Ass. professor Turid Worren (From Oct.)
Professor emeritus Johannes Falnes
Professor II emeritus Reidar Nydal (Deceased May)
Professor emeritus R. Svein Sigmond

Guests:
Scientist Sverre V. Pettersen (from Oct.)
Dr. Jonas Ørtegren (Post doc)
Dr. Roland Wittje (Post doc)

Overview

The research is mainly carried out within the fields of *electron and ion physics, energy and environmental physics, experimental optics* in addition to *didactics of physics*. These contain several subfields with a large variety of topics. A brief overview is given. For the year 2004 we have chosen to give a more extended description of two research topics: Experimental optics and environmental physics

Survey of research activities

The research is focused on several different topics as electrical breakdown in fluids and gases (*Løvaas, Sigmond*) and transport of ionized gases (*Skullerud*). Research on video holography, and fibre optics interferometry are being performed (*Løkberg*). Signal transmission and processing methods for electromagnetic sea bed logging, coherence theory, and statistical models for the signal processing and speckle statistics in optical coherence tomography (*Pedersen*). A new research group in experimental optics was established during the year with a new laboratory for fs laser based time resolved luminescence spectroscopy (*Lindgren*). Thermal fluctuations in mixtures of alkanes and in natural gas in gas phase and in condensed phase, as well as on the interface, are studied by laser light scattering. Measurements are performed at reservoir conditions (*Strand*). Renewable energy sources as wind, solar radiation (*Løvseth*) and ocean waves are studied (*Falnes*) and in addition a new activity on third generation solar cells have started (*Worren*). Ultraviolet (UV) climatology is studied with emphasis on processes affecting transmission of ultraviolet radiation to the surface, particular the importance of aerosols and clouds. (*Kjeldstad*). 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*).

Experimental optics

(*Mikael Lindgren*)

In this group we are interested in developing measurement systems, and applications within bio-sensing and materials characterization. Furthermore, we are developing experimental techniques for studying fundamental multiphoton processes, as well as utilizing novel photonics technology, mainly polarization and phase changing devices, in our detection systems. A high repetition rate fs-pulse laser with extensive wavelength tunability is used in conjunction with single photon counting techniques to directly measure a variety of molecular properties and multiphoton processes from the emitted fluorescence of various excited molecular systems. Two examples from on-going projects are summarized below.

Together with the protein chemistry group at Linköping University, Sweden (Hammarstrøm et al) we are studying the physical state of model proteins for amyloid precursor states. These can initiate diseases such as senile systemic amyloidosis, familial amyloidotic polyneuropathy (FAP) and related. The structural and physicochemical characteristics of prefibrillar amyloidogenic oligomers and protofibrillar aggregates are investigated using fluorescence spectroscopy. In Fig. 1 the anisotropy decays of a conformational probe, 1-anilinonaphthalene-8-sulfonate (ANS), trapped in aggregates of TTR, are shown. The different curves represent different concentrations of the protein monomer.

With support from the Norwegian Research Council (NanoMat) we are developing novel photonic nanomaterials based on dendritic polymers and nanoporous silicate and titanate materials. This is a collaboration project with the Polymer Technology at KTH, Stockholm and the Ugelstad Laboratory at NTNU. The materials are based on sol-gels developed from dendritic templates, or vice versa. Photonic functionality is included for two purposes: diagnostic characterization of pore structure and applications based on optical function.

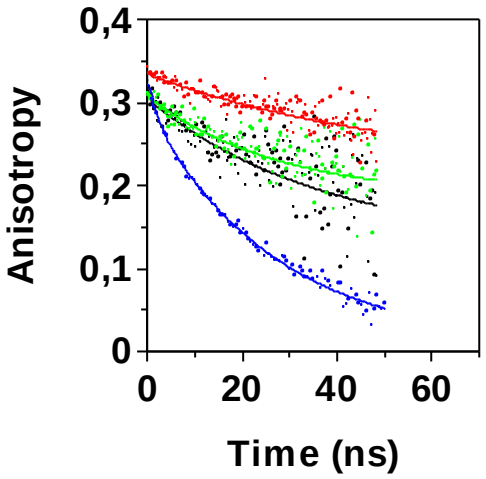


Fig. 1. ANS anisotropy of aggregates of A-state TTR: 2 mM (Black), 4 mM (Green) and 8 mM (Red). Native tetrameric TTR is shown in blue.

Figure 2 (top) shows the AFM picture of highly ordered hybrid inorganic-organic isoporous membranes. These can be made in terms of photonic band-gap structures as the pores (empty in this case) form a regular "crystalline" structure. The lower portion shows the associated diffraction pattern obtained by a coherent laser beam in the visible.

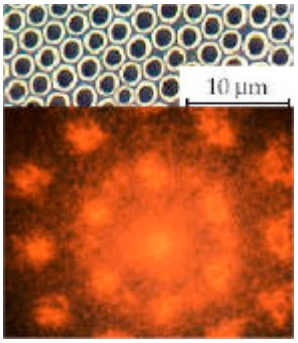


Fig. 2. Image of hexagonally close-packed pores (top) giving a diffraction pattern at 633 nm (lower).

These and related hybrid nanomaterials are being functionalized with phosphorescent metal centers such as Eu^{3+}, Er^{3+}, Nd^{3+}, $Ru(bpy)_3^{2+}$ as well as various fluorescent organic dyes and pigments, predominantly for light amplification and bio-sensing applications.

Environmental physics – Factors affecting ultraviolet radiation.

(*Berit Kjeldstad*)

Focus of the Environmental Physics group has been towards solar ultraviolet radiation (UV) and the factors affecting the amount radiation reseaching the ground. Exposure to ultraviolet radiation might cause skin damage and photoinhibition in many organisms including plants, phytoplankton and bacteria, depending on the dose. Amount of UV vary during the day and year due to solar elevation but also atmospheric factors as ozone, clouds, aerosols and ground reflections give significant variability in UV irradiance. In a project funded by NFR in collaboration with Norwegian Institute of Air research, Norwegian Radiation Protection Authority and University of Oslo these factors are investigated, and the NTNU groups is focusing on the effect of aerosols. Instrumentation has been developed for measurements of spectral aerosol optical depths and particular emphasis is put on the ultraviolet part of the solar spectrum to study absorption and scattering properties of aerosol in this part of the electromagnetic spectrum. The groups is also participating in a EU project INSPECTRO looking at effects of clouds on UV irradiance on the ground and in space. In the project 3D models of radiative transfer in clouds as been studied and the NTNU group has participated in validation measurements of the model. UV measurements above, within and below the clouds as well as ground based measurements were performed. In Fig.3 a picture from the measuring campaign in Bayern May 2004 is shown.

Fig.3. From a validation campaign in Bayern May 2004, EU project INSPECTRO.

Preliminary results indicate that the 3D radiative transfer model simulate scattered cloud conditions and calculate the UV irradiance at the ground within satisfactory uncertaines.

The group has performed the first UV measurements in Nepal where effects of aerosols have been investigated indicating that UV levels are effected less by aerosols than predicted. The variability of aerosol optical depth in Katmandu is shown in Fig. 4.

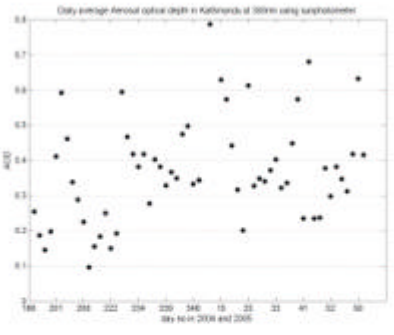


Fig. 4. Variability of aerosol optical depth in Katmandu, Nepal, during summer and winter season

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
Professor II Einar Rofstad
Professor II Arne Skretting
Professor II Tor Wøhni

Guests
Gunnhild Oftedal (Scientist)
Ingunn Tufto (Post doc)
Pawel T. Siorski (Post doc)
Ståle Ramstad (Post doc)

Overview

The research is divided in three main activities within biophysics and medical technology: *Biopolymers*: Studies of physical properties and organisation of biological molecules. *Medical technology*: Application of molecular and functional imaging to study properties and distributions of molecules in cells and tissue. *Biosystems*: Studies if 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

Biological polyelectrolyte complexes and interactions
(*Bjørn Torger Stokke*)
During 2004 focus has been on research within structural organisation and function of biopolymers including mechanism and competitive effects within polyelectrolyte complexation, compaction and multilayers, and single-molecule force spectroscopic studies of protein domain epimerase functionalities towards high molecular weight polysaccharide substrates.

Medical technology

Transport of macromolecules in tumour tissue
(*Catharina de Lange Davies*)
The low and heterogeneous uptake of therapeutic macromolecules is a major obstacle to successful cancer therapy. We have previously shown that the enzymes collagenase and hyaluronidase which disintegrate extracellular matrix reduce the interstitial and microvascular pressure thereby inducing a transcapillary pressure gradient which improves the uptake of therapeutic molecules. This year we studied the effect of the enzymes on diffusion using "fluorescence recovery after photobleaching", on transient perfusion using confocal and multiphoton microscopy, and on vascular volume and vascular transfer rate using magnetic resonance imaging. Collagenase seems to be more efficient than hyaluronidase in changing these transport parameters.

Functional optical coherence tomography (OCT)
(*Tore Lindmo*)
OCT is extended from structural to functional imaging. By combining the OCT signal with a mathematical model of the one-dimensional diffusion process, we are able to determine the diffusion of the dye Aluminum Phthalocyanine Tetra-sulfonate Chloride placed on the top of an agar gel. The motivation for our work is to be able to measure in vivo concentration profiles during uptake of photosensitizers in photodynamic therapy. A detailed description of this project appeared in last year's report under the Division of Applied and Didactic physics.

Biosystems

Plant growth reactions in weightlessness
(*A. Johnsson, B. Solheim*)
In an experiment for the International Space Station, we will study the rotational and oscillatory movements of plants growing in weightlessness. The study, in collaboration with the BioCenter at the Department of Biology, focuses on the importance of gravity for growth processes at genetic, cellular and organism level. We develop hardware to be used in the mapping of the movements both in weightlessness and on centrifuges on board the Space Station. Modelling and simulation of growth will be carried out, also on plants growing under laboratory conditions on the earth.

Photoinduced reactions in bacteria
(*A.Johnsson, S. Ramstad*)
Photoreactions in bacteria and possible mechanisms for their destruction by light are studied. The project was presented in the Year Report 2003.

Photophysics of important pigment systems
(*Kalbe Razi Naqvi and Thor Bernt Melø*)
Despite the disparity in their chemical structures and spectral characteristics, tocopherols and carotenoids are both believed to function as general-purpose antioxidants and photoprotective agents, but most previous research has concentrated on carotenoids. We have continued our studies of alpha-tocopherol, the

most important form of vitamin E, based on our findings last year which imply that vitamin E could be involved in photoprotection.

Studies have also continued on contacts between pigments in photosynthetic systems. These inter-molecular interactions determine the transition probabilities of various radiative. and nonradiative processes (for instance, transfer of an electron or energy from one chromophore to another).

A quantitative description of scattering of light by pigmented cells has resulted in successful simulation of scatttering spectra of many systems (human erythrocytes, chloroplasts and subchloroplast particles, algal cells) over a wide spectral range.

Age-related macular degeneration (AMD)
(*Arne Valberg*)

An EU-supported Concerted Action on "Photoreceptor Dynamics in AMD" has been continued. An aim of our contribution to this study was to analyse photoreceptor damage by means of multifocal electroretinograms (mfERG) using the VERIS-system. However, when recording from a collection of single cone types, a nasal-temporal latency asymmetry may represent an obstacle when trying to assess disease-induced changes in the responses to cone-isolating stimuli.
The study of the unexpectedly great loss of colour vision in persons with AMD was continued.

Visual Evoked Potentials (VEPs) to chromatic and achromatic stimulation
(*Arne Valberg*)

The idea that magnocellular and parvocellular information channels from the retina to the brain can be revealed by the components of the scalp VEP was pursued at different luminance levels, from photopic (daylight) vision to low scotopic (night vision) light levels. This study concluded that, contrary to expectation, parvocellular pathways are sensitive enough to evoke a major VEP-response at low light levels.
A neural model that was developed to account for the VEPs to stimuli combining luminance and chromatic contrast suggests that parvocellular pathway signals may underlie the oddity of response amplitude asymmetry relative to equiluminant stimuli.

Examples of research carried out in 2004

1. Biological effects of electromagnetic fields
By A. Johnsson, A. Straume and G. Oftedal

Possible health effects from *weak* electromagnetic fields are a general concern while strong fields undoubtedly cause biological effects of different nature. The studies focus on possible effects in some frequency regions.

Possible health effects caused by use of mobile phones.

Among reported symptoms warmth sensations and headaches are most prominent. We have completed a double-blind study of the skin temperature increase caused by a mobile phone using infrared camera technique. Reported increase in skin temperature (typically a few ^{0}C) could be due to thermal insulation by the phone, heating of the mobile phone resulting from its electrical power dissipation, and radio frequency (RF) exposure. The insulation and the electrical power dissipation lead to statistically significant rises in the skin temperature, while the RF exposure did not. The last alternative was investigated by replacing the antenna of the mobile phone with a 50 Ω resistive load.

Figure 1 shows skin temperature changes of a person holding a mobile phone, switched on but without emitting radio frequencies. No additional temperature effects were noted when the phone was emitting at 900 MHz.

Currently a double blind provocation study is carried out in collaboration with Department of Neurology, St Olavs Hospital. The study is designed to investigate whether the radio frequency fields from mobile phones may cause headaches, changes in the blood pressure and/or changes in heart rate. Type of headaches experienced will also described and classified.

Mapping of low frequency magnetic fields

Mobile phones show broad spectrum fields. The possible biological effects are dependent on the frequency and the intensity. The magnetic low frequency fields (below 400 Hz, with a peak at 217 Hz) around mobile phones were mapped. The field levels are compared with international guide lines.

Low frequency (50 Hz) magnetic fields in an outdoor city environment were studied. Large seasonal variations were recorded, mainly due to higher power consumption in the wintertime. Transformer stations as well as electric heating of pavements affect the exposure of the general public. The magnetic flux density values are lower than required by safety guidelines.

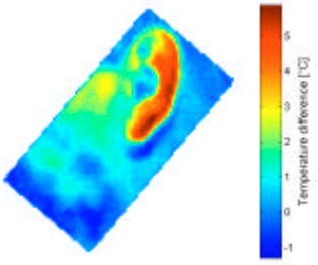


Fig.1. Skin temperature changes of a person holding a mobile phone to his ear for 30 minutes. The mobile phone was on, but not emitting signals. Additional temperature effects were not observed at 900 MHz emission. Temperatures are relative to the other ear.

2. Single-molecule force spectroscopy: biopolymer interactions

By B. T. Stokke

The function of biopolymers is intimately connected to their ability to interact. Important examples include higher order structure formation, as e.g. assembly of microtubuli and base paring in duplex DNA, biopolymer-ligand interactions for initiation of cellular signalling and antibody-antigen interactions in the immune system. Recent advances in e.g. biomembrane force probe, optical tweezers and scanning probe-based techniques support experimental determination of interaction forces from a few pN to several nN. The energy landscape of the physical forces governing the interaction along the unbinding pathway can be determined using various force loading rates.

Dynamic force spectroscopy using an AFM based approach has been applied to study alginate-epimerase non-covalent interactions (Fig 2). Alginates are structural polysaccharides abundant in seaweed and certain species of Azotobacter. The biosynthesis of these proceeds by polymerisation to the homopolymer mannuronan followed by epimerasation at the polymer level.

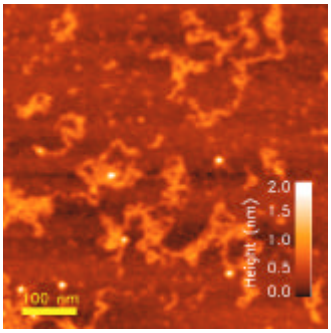


Fig. 2. Enzymes at work. AFM topograph showing flexible mannuronan polysaccharides with epimerase AlgE4 bound (bright dots).

Epimerase Alge4 introduces a regular alternating sequence, either by preferential attack, or processively by converting several residues before detaching. The experimental procedure was optimized to yield unbinding of single-molecular pairs by controlling the grafting densities of the components (Fig. 3). The specificity of the interaction was proven by a competitive assay as well as using other types of materials. The specific unbinding between molecular pairs of mannuronan and AlgE4 as well as its two modules, A and R, was studied. The mean protein-mannuronan unbinding forces were determined to be in the range 73 - 144 pN, depending on the protein, and increased with increasing loading rate. The ratio between the epimerase – mannuronan dissociation rate and the catalytic rate of epimerization of single sugar residues suggests a processive mode of action of the AlgE4 epimerase, associated with the A-module. Dynamic force spectroscopy applied to study the interaction between the AlgE4 enzyme and its substrate illustrates the potential of the technique.

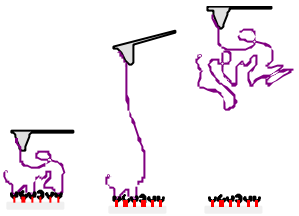


Fig. 3 Schematic illustration of the unbinding experiment between epimerases AlgE4 attached to the mica surface (bottom) and mannuronan attached to the AFM tip (top) that is retracted from the surface (events towards right).

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
George Batrouni (Onsager professor, 6 mnd)
Jon Are Beukes (scientist, from Nov.)
Ahmed Gmira (Post doc)
Yves Meheust (Post doc)
Morten Kildemo (Post doc)
Stine Nalum Næss (Post doc)
Srutrashi Pradhan (Post doc)

Overview

The research is focused on the *Physics of Soft and Complex Material*s including *Biological Physics.* The studied phenomena 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. In 2004 one doctoral student has fulfilled with excellent results and part of the theory and simulation results are published in Macromolecular Theory and Simulations with a cover page picture (Fig. 1)

Fig. 1 Front page of Macromolecular Theory and Simulations, Vol. 13, 2004

Synthetic clays; Experimental investigations of soft materials and complex systems
(*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 AFM and a new modular rheometer was installed during 2004. A new SAXS system was ordered in 2004, and will be installed in 2005.

Brittle fracture, mechanical properties of granular media, two-phase flow in porous media, econophysics

(*A. Hansen*)

The main research interests for 2004 have been concentrated on brittle fracture and on two-phase flow in porous media, in addition to granular flow problems. We have also initiated an activity on econophysics. The fracture project is described in detail below. The two-phase flow problems concern the further development of a pore-scale flow simulator which will use lattice Boltzmann techniques to resolve the interface dynamics at junctions where the two phases meet. The granular flow problems are connected to the gravitational motion of charged grains. This is a technologically important problem occurring e.g. in the three-dimensional printing process. We are at present studying certain network topologies using Boltzmann methods. This study goes under the heading of econophysics.

Crystallographic studies of phase transitions, instrumentation.

(*F. Mo*)

Research activities included studies of a) structural phase transitions in a ferroelectric material, and b) crystallinity, melting and recrystallization of a polymer as a function of different processing conditions and properties of the polymer. A gas-flow thermostat (Peltier elements) sample cell with control of relative humidity has been constructed for diffraction experiments with crystals that are unstable and denature easily upon changes in temperature and/or relative humidity under X-radiation. In 2004 the cell has been further developed to include a transparent, rotatable capacitor allowing an electric DC-field to be applied to the crystal in a fixed crystallographic direction during the experiment. With this novel cell diffraction data of unprecedented quality were collected previously for the HT paraelectric phase of Rochelle salt, and recently also for its ferroelectric phase. The experiments have shown that the ferroelectric phase is extremely sensitive to X-rays, which apparently promote a transition to an orthorhombic phase for which we have also acquired data for a detailed structure investigation.

Electronic properties and chemical reactivity of surface alloys

(*S. Raaen*)

Several surface alloys have in recent years been investigated by photoelectron spectroscopy, low energy electron diffraction, and thermal desorption spectroscopy. Of special interest has been alloys based on thin overlayers of rare earth metals on catalytic active transition metals. It has been shown that the electronic structure as well as chemical reactivity may be dramatically altered. Rare earths are ideally suited for formation of surface alloys in view of their relatively low surface free energies. A recent result is that self assembled nano-structured surface alloys form in the La-Rh(100) system. Some progress has recently been made in analyzing temperature programmed desorption data by use of Monte Carlo simulations.

Collective Effects and self-organized critically in traffic flows

(*Bo-Sture Skagerstam*)

We have focused our attention on large-time statistical properties of traffic flows (work done in collaboration with A. Hansen) to be described below in the report from the Division of Complex Materials. In this study use have been made of the so-called Hurst exponent to classify the large-time properties of traffic flows and properties of stochastic differential equations. In particular a generalized version of the fluctuation-dissipation theorem could be used to describe the scaling behaviour of the statistical fluctuations of the sound-noise the traffic flows generate. We have also studied various collective effects of atoms interacting with one and the same micro-cavity radiation field (cavity electrodynamics). The effect of e.g. detection efficiencies has been taken into account in great detail. Noise-properties of statistical mixtures in quantum optics have also been studied and it has been shown that minimal-dispersion can be obtained only for pure quantum states. A research project on the human eye as a quantum-mechanical detector of photons has also been initiated. We now believe that we have a predictive model for the response of the human eye on low intensity (quantum) light.

Example of research carried out in 2004

Statistical properties of Traffic Flows – the appearance of 1/f-noise and self-organized criticality

By Bo-Sture Skagerstam

The properties of traffic flows can be studied by means of e.g. visual real-time monitoring. This is a common but rather expensive method used in areas with very heavy traffic and where a regulation of traffic flows is required. In 2004 we proposed a very cost-effective

method to be used in order to obtain statistical traffic-flow information simply by measuring the sound these traffic-flows produce. In collaboration with the industry we have found out that such measuring techniques easily can be integrated with current traffic-flow observational techniques. We have performed such sound measurements. A typical set of experimental data of a one-lane situation is given in Fig.1, where *L(t)* is the sound sound-level in decibel.

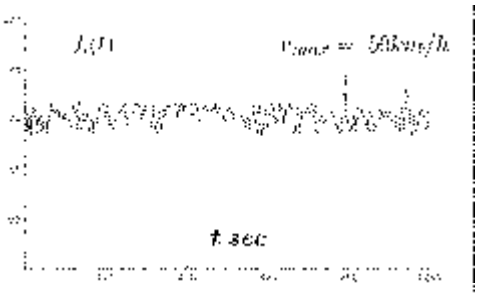


Fig. 2. A typical set of experimental data of a one-lane situation, where L(t) is the noise of sound-level measured in units of decibel.

We have also confronted our theoretical analysis with data from computer simulations in which case it is easier to vary external parameters like traffic intensity, limits on velocities etc. The theory of stochastic differential equations, with memory effects included, turns out to be a convenient theoretical platform for the analysis of the data combined with scaling properties of self-affine systems characterized in terms of a so called Hurst exponent. Hansen and collaborators have, over the years, shown that such a scaling concept plays an important role in the understanding of e.g. roughness properties of materials and their fracture mechanisms. The work by Morgado et al. (Phys. Rev. Lett. 89, 100601 (2002)) has been adapted to our model of traffic flows. We have found that fluctuations in the sound noise of traffic flows are directly related to the large-scale time properties of the Mori-Lee memory function. Of particular interest is that our observations support the presence of a 1/f-noise in traffic flows, i.e. traffic flows enters into a stage of self-regulative behaviour at large time-scales. Wavelet transform techniques enables us in a straightforward manner to extract this scaling behaviour as seen in e.g. Fig.2, where *W*[*L(t)*](*a*) denotes the wavelet transform of the data at a time-scale a and *N* is the number of data points.

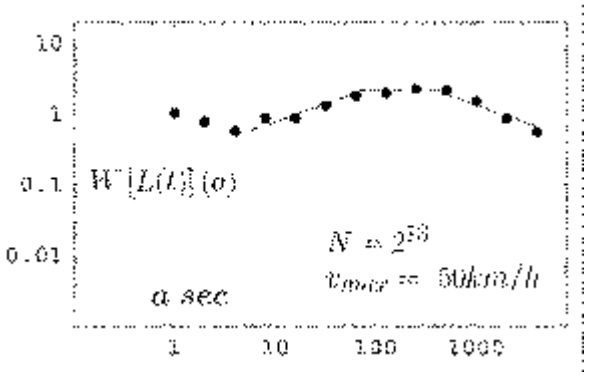


Fig. 3. The scaling behaviour of the noise of sound from a one-lane traffic flow, where W[L(t)](a) denotes the wavelet transform of the data at a time-scale a and N is the number of data points. The traffic flow is regulated by a velocity limit.

DIVISION OF CONDENSED MATTER PHYSICS

Staff
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Professor Kristian Fossheim
Professor Randi Holmestad
Professor Ola Hunderi
Professor Emil J. Samuelsen
Assistant professor Bård Tøtdal
Professor II John Walmsley
Professor emeritus Ivar Svare
Guests
Dr. Trine Andersen (Post doc) (From August)
Dr. Ton van Helvoort (Post doc)
Dr. Nils Sandberg (Post doc)
Mr.Bjørn Soleim (Siv.ing.) (From July)

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 for studying physical properties of materials and material structures. A brief survey of the research is given. For the year 2004 two research projects are described in more details.

Superconductivity

(*K. Fossheim*)
In superconductivity context at NTNU one event stands out as most significant during the year 2004: The publication of a Wiley textbook at the PhD-level by Kristian Fossheim and Asle Sudbø. Already after a few months most of the first printing was sold, a certain sign of having been adopted by the international physics community. A second printing will be produced early in 2005. According to sales statistics the book competes with classics like those by Tinkham and de Gennes. It is available on internet stores worldwide.

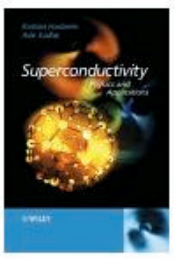

Fig.1 The cover of the textbook on superconductivity

Transmission electron microscopy (TEM)

(*R. Holmestad, B. Tøtdal, J.Walmsley*)
The activity includes nanoscale structure studies within materials physics and the connection to the macroscopic properties:

- Micro- and nano structure studies of functional perovskite materials: ferroelastic sintered materials, ferroelectric thin films
- Materials for hydrogen storage (alanates)
- Membranes for hydrogen separation
- Bonding in materials studied by convergent beam electron diffraction (CBED)
- Analysis of alloy nanoparticles in catalysts
- Structure and morphology of carbon nanotubes
- Solar grade silicon
- Alloy development, nucleation of precipitates in aluminium alloys; structure determination of metastable, hardening phases
- Atomistic modelling and *ab initio* methods in materials science
- Surface studies of light metals; nanoscale oxide layers, and corrosion behaviour.

The field emission transmission electron microscope (FE-TEM) offers a small probe, along with energy filtering, spectroscopic imaging and X-ray mapping from small regions. 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.

Plasmonic photonic crystals

(*Ola Hunderi and Turid Worren*)
I this project we have produced plasmonic-photonic crystals by monodispersoid nanosphere lithography. Monodispersoid spheres of diameter 1 ? m were dispersed on a silicon substrate in a closepacked hexagonal structure. A metal film was deposited on this structure by thermal evaporation. The spheres were then removed. The hexagonal structure of spheres acted as a shadowing mask during deposition of the metal film and we are left with the hexagonal structure of metal islands shown in the image below. This structure is a two-dimensional photonic crystal. For free electron like metals like aluminium and the noble metals these structures will show strong plasma resonances in the optical spectra. According to the so-called Babinets principle, the spectra will be resemble the spectra of a metal film with holes, a structure that has attracted considerable attention lately.

This project was done in collaboration with Ragnar Fagerberg, SINTEF

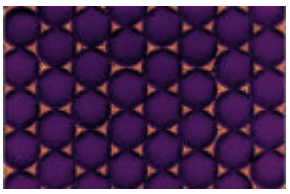

Fig. 2 Image of the hexagonal replica of a metal island

Methanol adsorption on NiAl alloy surfaces

(*A. Borg*)

The interaction between metanol and ordered NiAl(110) and Ni_3Al(111) surfaces has been investigated by photoemission spectroscopy measurements, performed at the MAXII synchrotron radiation laboratory, Lund University, Sweden, and through density functional theory (DFT) calculations. In the first monolayer, methanol is found both to decompose to methoxy and coadsorbed hydrogen and to adsorb molecularly on the substrate at a temperature of about 120K. The photoemission spectra show bonding between substrate Al atoms and the methanol and methoxy species. DFT calculations on the interactions with tbe NiAl(110) substrate show methanol to occupy on-top Al sites. Methoxy is located in Al-Al short bridge sites with en energy of adsorption of 3,19 eV and an Al-O bond length of 1,95 Å. Similar calculations are in progress for adsorption on Ni_3Al(111).

Polymeric and molecular organic semiconductors

(*E. J. Samuelsen*)

The research has recently focussed on self-assembling of organic semi-conducting polymers deposited as thin films is carried on at Risø National Laboratory by D. Breiby. At NTNU attempts were carried through to produce micro-fibres by electro-spinning: Solution of the polymers are ejected from a syringe needle in a controlled way, under the influence of 10-40 kV tension. As the solvent rapidly evaporates during the drop flight along the field, sub-micrometer fibres can be obtained. As it turned out, fibres of the relatively short semi-conductive polymers POT were quite difficult to obtain in substantial quantities, whereas fibres could be spun this way of high molecular weight polystyrene (PS). Consequently, composite fibres of the two kinds of polymers could be spun from a common solvent tetrahydrofuran THF. A phase separation takes place, however, at PS contents less than 40 % The composite fibres become conducting. upon doping by iodine vapour.

A small-angle x-ray scattering instrumentation (SAXS), of the trade mark NANOSTAR, to be installed at the rotationg anode x-ray generator was ordered for delivery early 2005.

Examples of research carried out in 2004

1. Ultrafast photomagnetic control of spins

By Fredrik Hansteen

Ultrafast (10^{-12} sec and faster) magnetization dynamics and the search for mechanisms of high speed magnetic switching have become topics of ultimate interest in both condensed matter physics and information storage technology. Laser-induced switching has until now been achieved only through thermal mechanisms. These are limited in speed by the phonon-magnon interaction time. In metals this time is typically of the order of a few picoseconds and in dielectrics typically several hundreds of picoseconds. Another problem is that the repetition rate is severely limited by the time it takes for heat to be transported away. The existence of nonthermal mechanisms of interaction between light and spins could lead to a solution of these problems.

In this work highly transparent magnetic garnet films have been studied using an all-optical pump and probe technique. When excited with ?=805nm 100fs laser pulses coherent precession of the magnetization is triggered. The excitation of the magnetic system takes place on a timescale of at least 3 orders of magnitude faster than the phonon-magnon interaction time. This, combined with the observation that precession amplitude and phase depend on the laser polarization, rules out the possibility of a simple thermal excitation mechanism.

By studying the precessional dynamics in different geometries and under various conditions two *ultrafast* and *nonthermal* photomagnetic mechanisms have been identified:

1.Photo-induced magnetic anisotropy.

2.Optically generated magnetic field pulses.

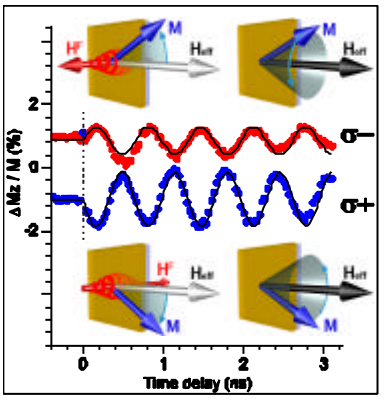

Fig. 3: Precession of the magnetization following excitation with circularly polarized light. The two helicities s^+ and s^- give rise to precession with opposite phase and different amplitude.

Linearly polarized light modifies the magnetocrystalline anisotropy and creates a new long-lived equilibrium state for the magnetization. The

direction of this photo-induced magnetic anisotropy depends on both the plane of polarization of the laser pulses and the orientation of the magnetization with respect to the crystallographic axes of the garnet film. Circularly polarized laser pulses act as strong transient magnetic field pulses of about 0.6T during their presence in the film. Simultaneously they also modify the magnetic anisotropy.

These two effects can be combined to achieve complete optical control of the magnetization on the femtosecond timescale. We have demonstrated an approximately 1° switching of the magnetization within 100fs and using only a single laser pulse. The magnetization remains stable in the new state for several nanoseconds until the photo-induced anisotropy relaxes.

2. Electron Microscopy studies of alanates with V-based additives *

By Carmen Andrei, John Walmsley and Randi Holmestad

Concerns over global warming and air pollution have stimulated the introduction of the concept "Hydrogen Economy", which, if implemented, gives a number of environmental benefits. Alanates, which are hydrides of aluminium, are most promising compounds for hydrogen storage, due to their low weight and high storage capacity. Addition of transition metals improves the hydrogen release and may also provide reversibility of the decomposition process. The role of the transition metal in the reaction kinetics as a catalyst or a dopant is not yet understood.

In this work, the microstructures of the alanates are extensively studied in order to explain the role of the transition metal. The example below illustrates the microstructure of $LiAlD_4$ with VCl_3 additives. The system has been studied in different steps of the decomposition process using advanced electron microscopy techniques: electron energy loss spectroscopy (EELS) imaging in the scanning transmission electron microscopy (STEM) mode, with simultaneously acquisition of the energy dispersive X-ray spectroscopy (EDS). Energy filtered transmission electron microscopy (EFTEM) was used to show elemental distributions in the samples. The spatial distribution of the additives and the main elements within the alanate particles was examined with a resolution of a few nanometers.

Figure 4 shows a STEM image of a $LiAlD_4$ particle with VCl_3 additive. EELS spectra in Fig 5 reveal the chemical state of Al, O and the additives. As shown in Fig. 6, V does not appear to mix chemically with Al to a significant degree. Most of the additive was in the form of VO or V_2O_3 and it was found to be highly concentrated in just a few particles. This is consistent with the suggestion that V oxides may influence the kinetics of the process, by being present at very low levels in the alanate phase, particularly where the oxides are formed at the sample surface. Our observations illustrate that advanced electron microscope techniques provide powerful yet demanding tools for understanding the properties of these materials.

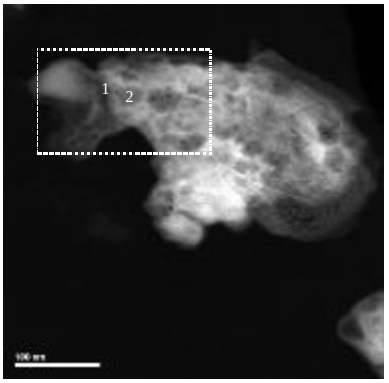

Fig. 4. Dark field STEM image of $LiAlD_4$ with VCl_3 additive. The spectra in Figure 2 are from the positions indicated. The dashed area was used to acquire the EFTEM map in Fig.6.

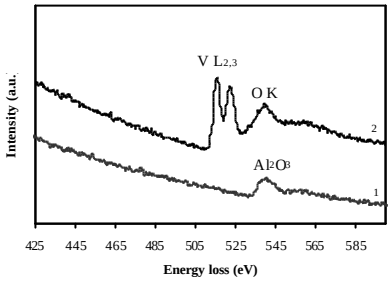

Fig 5. EELS spectra taken in positions 1 and 2 in Fig.4 showing V $L_{2,3}$ and O K edges.

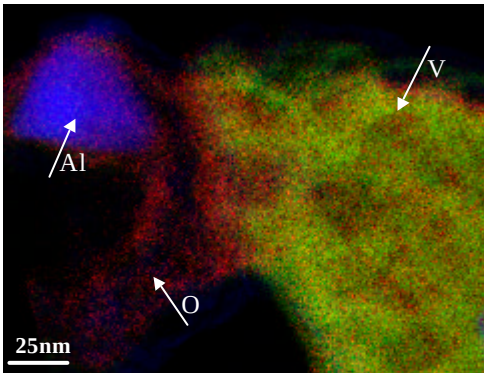

Fig.6. (corresponding to dashed area in Fig. 4). Color coded image resulting from the superposition of the three maps for O (red), V (green) and Al (blue). Strong overlap of the O and V signals give rise to the yellow region.

*This work is done in collaboration with D. Blanchard, H. Brinks and B. C. Hauback at IFE, Kjeller and G. Botton at McMaster University, Canada.

DIVISION OF THEORETICAL PHYSICS

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Professor Kjell Mork (until August)
Professor Jan Myrheim
Professor Kåre Olaussen (Sabbatical until August)
Professor Asle Sudbø
Ass. Professor Jon Andreas Støvneng
Ass. Professor Sigmund Waldenstrøm
Ass. Professor Ingjald Øverbø
Professor II Roger Sollie
Professor emeritus Per Chr. Hemmer
Professor emeritus Kjell Mork (from September)
Professor emeritus Haakon A. Olsen

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Dr. Albert Reiner (Post doc)
Dr. Tommy Øvergård (Scientist)
Dr. Dag Østvang (Scientist)

Overview

The year 2004 was a good one for the Division of Theoretical Physics. Among several highlights we mention: - the publishing of a new modern textbook on Superconductivity by Kristian Fossheim and Asle Sudbø; - Arne Brataas was appointed *Yngre Fremragende Forsker* (Young Exellent Researcher) as one of only two at NTNU; - Brataas and Sudbø were awarded a *Center of Advanced Studies* project for the year 2006-2007 (on *Spin and Charge Flow in Nanostructures*); - the pioneering work on hydrogen by Asle Sudbø and collaborators was presented on the front page of the October 7th issue of Nature, Fig.1.

Fig.1 Front page of Nature Oct 7 2004

Research is mainly carried out within the broad fields of *Condensed Matter Physics*, *Statistical Physics*, and *Quantum Physics*. These contain several subfields with a large variety of topics. A brief overview is given. For the year 2004 we have chosen to give a more extended description of one topic.

Survey of research activities

The SCOZA (self-consistent Ornstein-Zernike approximation) is used for further study of fluids and lattice gases (*J. S. Høye*).

Pair correlation function and equation of state for polymers are evaluated by a new method. The polymer fluid is regarded as a simple fluid consisting of monomers by which solution of the Ornstein-Zernike integral equation for simple monatomic fluids can be utilized. (*J. S. Høye*).

The thermal behavior of the Casimir force between metallic surfaces has been studied (*J. S. Høye*)

Quantum transport in nanostructures and spin injection and spin dynamics in normal metals, semiconductors and superconductors are considered. We published several articles, of which *three* in Physical Review Letters (*A. Brataas*).

Among several aspects of strongly correlated condensed matter systems being studied, the most spectacular recent results are for the system of liquid metallic hydrogen, where the electrons and protons may form independent condensates (since each species is separately conserved). This leads to a very rich phase diagram and completely new phenomena, such as the simultaneous existence of superconducting and superfluid behaviour. The quantitative analysis of such systems is carried out by large scale Monte Carlo simulations of effective gauge theories (which encapsulates the relevant degrees of freedom and dynamics for such systems). In 2004 the research group of Asle Sudbø produced several papers, including one for Nature and three for Physical Review Letters (*A. Sudbø*).

The behaviour of a quantum particle in the presence of two magnetic impurites is investigated (*J. Myrheim*).

The low density behaviour of a mixture of anyons with different statistics is studied to third order of the virial expansion (*J. Myrheim, K. Olaussen*).

Matter at high density in strong magnetic fields (neutron stars) is studied (*J. Myrheim*).

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*).

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

We use density functional theory to do quantum chemical modeling of systems related to polymerization and catalysis (*J. A. Støvneng).*

A crossover behaviour was found of burst avalanches in a material about to break down. The number of elements breaking down simultaneously in an avalanche follows a power law with a certain exponent. It was found that this exponent changes just before complete breakdown (*P. C. Hemmer, A. Hansen* and *S. Pradhan*).

Example of research carried out in 2004

Density functional theory and catalysis

By J .A. Støvneng

Density functional theory (DFT) has become a favorite method for doing electronic structure calculations, for atoms, molecules, and condensed matter, within physics, chemistry, and materials science. Traditional ab initio methods are based on the Hartree-Fock approximation in which the exchange energy is treated exactly whereas the correlation energy is neglected. Improvements beyond Hartree-Fock are typically based on perturbation theory, but the computational effort scales very unfavorably with the size of the system. Practical implementations of DFT start from the local density approximation (LDA) where the exchange and correlation energies are those of the uniform electron gas. Improvements beyond LDA are to some extent empirical, but this pragmatic approach is necessary in order to handle large systems. The computational requirements increase more slowly with DFT than with Hartree-Fock based methods, and the accuracy/cost ratio is usually higher.

We have applied DFT to various aspects of organometallic catalysis. Metallocenes like Cp_2ZrMe_2 ($Cp = C_5H_5$, $Me = CH_3$) are used e.g. in polymerization of C_3H_6, producing polypropylene with desired material properties (e.g. thermal, mechanical, optical). The catalyst is made *active* by removing a methyl anion, producing the cation Cp_2ZrMe^+, which is able to link C_3H_6 molecules together and produce long polymer chains.

In a combined theoretical and experimental effort with the Dept. of Chemistry and the Dept. of Chemical Engineering, we have studied the activation of Cp_2ZrMe_2 in detail. An infrared (IR) active vibrational mode associated with the out-of-plane movement of the hydrogen atoms on the aromatic Cp ring turns out to be very sensitive to changes in the coordination of ligands around the transition metal (Zr). The activation process can therefore be monitored via *in situ* IR spectroscopy, by measuring the shift in the position of this particular band, with wave number in the range 797 - 832 cm^{-1}. DFT calculations within the harmonic approximation reproduce the observed experimental trend for several metallocenes and reaction products. An example is shown in the figures. Addition of the "cocatalyst" $B(C_6F_5)_3$ results in a stable complex Cp_2ZrMe - Me - $B(C_6F_5)_3$ in which one of the methyl groups is partly removed from Zr. The red arrows in Fig. 2 illustrate the vibrational mode. The lowest unoccupied molecular orbital (LUMO) in this complex is mainly due to an empty 4*d*-orbital on Zr, accounting for the electrophilic nature of the vacant site in the active cation (Fig. 3).

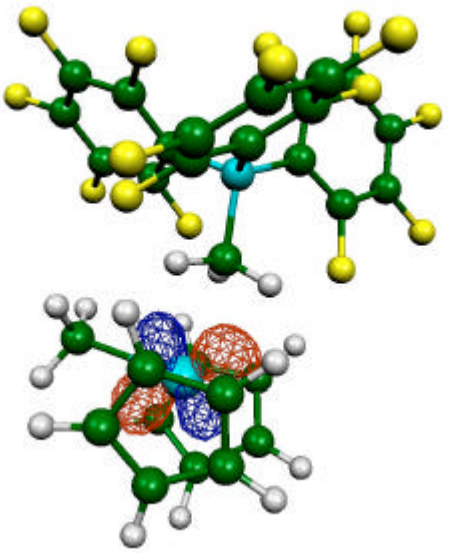

Fig. 2: IR active vibrational mode corresponding to out-of-plane movement of hydrogen on the C_5H_5 ring in the activated complex $(C_5H_5)_2ZrCH_3$-CH_3-$B(C_6F_5)_3$. Color code: Large blue: Zr. Small blue: B. Green: C. Yellow: F. White: H.

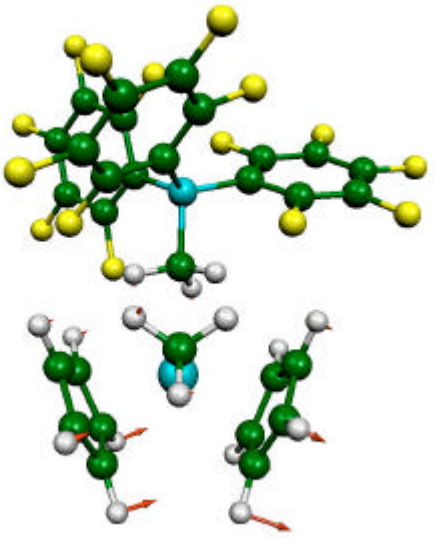

Fig. 3: Lowest unoccupied molecular orbital (LUMO) in activated complex. (Color code in Fig. 2).

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* Department of Physics and Engineering Physics, Chalmers University of Technology, Gothenburg Sweden

Brataas, A.:
* TU Delft, Nederland (G. E. W. Bauer), Theoretical Physics
* Basel, Sveits (W. Belzig), Theoretical Physics
* Budapest,Ungarn (G. Zarand), Theoretical Physics
* Universitetet i Lund, Sverige (K..-A. Chao), Condensed Matter Physics

Davies, C.:
* Dept of Internal Medicine with Oncology, Austria (G Baumgartner), Biophysics

Fossheim, K.:
* Institute of Microelectronics Technology, Moscow, Russia (Zhilyaev), Condensed Matter Physics
* Institute of Solid State Physics, Sofia, Bulgaria (Christova), Condensed Matter Physics

Fossum, J.O.:
* SNBL/ESRF France

Hansen, A.
* Universite de Nice-Sophia Antiplois, France (Batrouni)
* Ecole Normale Superieure, Paris, France (Schmittbuhl)
* Technical University of Budapest, Hungary (Kertesz)
* Nordita/NBI, Copenhagen, Denmark (Sneppen, Jensaen) Complex Systems, Condensed Matter Theory

Holmestad, R.
* TU Delft, The Netherlands (H. Zandbergen, J. Janssen) Electron microscopy
* Paul-Scherrer Institute, Villingen-PSI, Switzerland (P.Derlet), Atomistic modelling
* Århus University, Denmark (F.K. Larsen) Electron microscopy

Hunderi, O.:
* Techn Univ., Berlin (W. Richter), Surface Optics
* University of Nijmegem, (T.Rasing), Magnetooptics
* University of Liverpool, (P. Weightman), Surface Optics.

Johnsson, A:
* Arbetmiljöinstitutet, Umeå (K. Hansson Mild), Biophysics

Kjeldstad. B.:
* EU-prosjekt Educe and Inspectro., Environmental Physics
* University of Hanover, Meteorological Institute (Gunther Seckmeyer), Environmental Physics
* University of Thessaloniki, Department of Physics (Alkis Bais), Environmental Physics
* Univerity of Innsbruck, Institute of medical Physics, (Mario Blumthaler), Environmental Physics
* University of Manchester, Institutt of Science and Technology, (Ann Webb) Environmental Physics

Lindgren, M.:
* Linkopings Universitet, IFM (protein structure and dynamics)
* Kungliga Tekniska Høgskolan, Polymer Technology, Stockholm (dendritic nanomaterial)
* Kungliga Tekniska Høgskolan, Theroretical chemistry, Stockholm (multiphoton processes)
* Umeå Universitet, Organisk kemi, Umeå (photoprocesses, organic molecules)
* Totalforsvarets forskningsinstitut, Linkøping (bio-sensing; laser protecting materials and devices)
* Ytkemiska Institutet/Stockholms universitet, Stockholm, (hybrid nanocomposites)
* Université Claude Bernard(Lyon1), Laboratoire des Multimatériaux et Interfaces (sol-gel/hybrid materials)

Løvaas, T.H.;
KTH Stockholm, Alfvenlab. (S.Rosander), Electron Physics.

Løvseth, J;
* Risø Nationale Laboratorium, Danmark (Larsen), Wind Energy
* Danmarks Tekniske Universitet, Danmark (Hansen), Wind Energy

Mo, F.:
* SNBL, ESRF, Grenoble (J.A. Beukes, V. Dmitriev), Condensed Matter Physics

Naqvi, K.R.:
* Institute of Natural Resources and Agrobiology, Spain (J. B. Arellano), Biophysics
* Universidade de Coimbra, Portugal (L. G. Arnaut), Biophysics
* King's College, London (R. E. Dale), Biophysics
* Hungarian Academy of Sciences (G. Garab, T. Javorfi), Biophysics
* Universidade Nova de Lisboa, Portugal (ITQB), Biophysics
* Moscow State University, Russia (Mark N. Merzlyak), Biophysics
* Institute of Physical Chemistry, Spain (CSIC) (J. Gonzalez-Rodriguez), Biophysics

Olaussen, K.:
* Polish Academy of Sciences (Dr. A. Maciolek), Theoretical Physics

Samuelsen, E. J.:
* Linkøping University (O. Inganäs), Condensed Matter Physics
* Materials-Chem. Department, Mortsel, Belgium (L. B. Groenendaal), Condensed Matter Physics
* Univ. of Mining and Metallurgy, Krakow, Poland (W. Luzny), Condensed Matter Physics
* Experimental Division, ESRF, Grenoble, France (O. Konovalov and B. Struth), Condensed Matter Physics

Sigmond, R.S.;
* École Superieure d'Électricité (SUPELEC), Laboratoire de Physique des Gaz et des Plasmas, (A. And M. Goldman), Applied Plasma Physics

Skagerstam, B.S.;
* P.L. Knight, Imperial College, London
* P.K. Rekdal, Imperial College, London
* Gøran Wendin, CTH, Gøteborg, Sverige

Skullerud, H.R.;
* Universität Innsbruck, Inst. für Theoretische Physik (S.Kuhn), Plasma Physics

Stefansson, T;
* Univ. i Island, Haskli Islands, Reykjavik, Island (R. Olafsson), Didactics in Physics

Stokke, B. T.:
* Bristol Univ., UK (T. Atkins), Biophysics
* La Sapienza University, Roma, Italia (M. Dentini), Biophysics
* Munchen Techn. Univ., Tyskland (A. Bausch, E. Sackmann), Biophysics
* Univ. Joseph Fourier, Grenoble, Frankrike (E. Geissler), Biophysics

Sudbø, A.:
* Freie Universitaet Berlin, Tyskland (F. S. Nogueira, H. Kleinert, K.H. Benneman), Condensed Matter Theory
* Katholieke Universiteit Leuven (V. Moschalkov), Condensed Matter Theory
* Loughboro University, UK (F. Kusmartsev), Condensed Matter Theory
* Leiden University, Holland (J.Zaanen)

Valberg, A.:
* University of Freiburg, Germany (L. Spillmann and T. Otte), Vision Biophysics
* University of Tübingen, Germany (J Kremers), Vision Biophysics
* University of Utrecht, Netherlands (D. van Norren, T Berenschoot)
* University of Manchester, UK (I Murray, I Perry), Vision Biophysics

Africa

Løvseth, J;
* University of Durban Westville, Sør-Afrika (Heetkamp, Reinhardt, McPherson), Renewable Energy
* Eduardo Mondlane University, Mosambik (Cuamba), Solar Energy

America

Borg, A.:
* Materials Science Division, Lawrence Berkeley National Laboratory, Berkley, USA (M.Salmeron)

Brataas, A.:
* Harvard, USA (Y. Tserkvonyak, Bertrand I. Halperin), Theoretical Physic
* New York University (Andrew D. Kent)

Davies, C.:
* Harvard Medical School Boston, USA (R. K. Jain), Biophysics

Fossheim, K.:
* National High Magnetic Field Laboratory, Tallahassee, Florida, USA (Schneider-Muntau) Condensed Matter Physics

Fossum, J.O.:
* Brookhaven National Lab, USA (), Complex Materials
* University of Brasilia, Brazil, (), Complex Materials

Hansen, A.:
* Uni Ceara, Fortaleza, Brazil (Soares)
* University of Brasilia, Brazil (Oliveira)
* University of Arizona, USA (Franzikonis) Complex Systems, Condensed Matter Theory

Holmestad, R.:
* Arizona State University, Tempe, Arizona, USA (J.Spence, B.Jiang) Electron microscopy
* McMaster University, Hamilton, Ontario, Canada (G. Botton) Electron microscopy

Høye, J.S.:
* Stony Brook University, New York, USA. (G. Stell, F. Raineri, C.-L. Lee), Theoretical Physics
* Oklahoma University, Norman, Oklahoma, USA (K. A. Milton), Theoretical Physics

Lindmo, T;
* Beckman Laser Institue, University of California, Irvine (J. S. Nelson, Z. Chen), Biophysics

Skagerstam, B.S.:
* University of Florida (J.R. Klauder) USA
* Syracuse University, N.Y. USA

Stokke, B.T.:
* California, Irvine, California, USA (D. A. Brant) Biophysics
* Univ. of California, Santa Barbara, California, USA (H. Hansma), Biophysics

Sudbø, A.:
* John Hopkins University, USA (Z. Tesanovic), Condensed Matter Theory
* Bell Laboratories, USA (C. M. Varma), Condensed Matter Theory
* Brown University, USA (J. B. Marston), Condensed Matter Theory
* University of California LA, USA (J. O. Fjærestad), Condensed Matter Theory
* Los Alamos National Laboratory, USA (Z. Nussinov)
* Cornell University, USA (N.W. Ashcroft)

Tøtdal, B.:
* Lehigh University, USA (C.E.Lyman), Analytical electron microscopy

Asia

Brataas, A.:
* Nagoya, Japan (J. Inoue), Theoretical Physics

Fossheim, K;
* Department of Physics, University of Hiroshima, Japan (T. Suzuki , J. Hori), Condensed Matter Physics

Johnsson, A.:
* J. Nehru Centre for Advanced Scientific Research, Bangalore, India (V. Sharma), Biophysics

Naqvi, K.R.:
* International Islamic University Malaysia , Kuala Lumpur (T. Hj. Hassan), Biophysics

Stokke, B.T.:
* Osaka Prefecture Univ., Osaka, Japan (S. Kitamura), Biophysics
* Kyoto Inst. of Technology, Kyoto, Japan (K. Kajiwara) Biophysics

Australia

Skullerud, H.R.;
* Australian National University, Canberra, Atomic d Molecular Physics Lab., Electron and Ion Physics

National cooperation

* Photocure ASA, Oslo
* Division of Biophysics and Medical Technology, Radium Hospital, Oslo (Ø.Bruland, A.Skretting)
* Statoil Research Centre, Trondheim (F. Antonsen, H. Widerøe)
* University of Oslo (J.M.Leinaas, A.Dahlback, E.G.Fjelløy, K.J.Måløy)
* Optomed (R.Ellingsen, D.R. Hjelme, B. Falch)
* FMC Biopolymers (E. Onsøyen)
* Institutt for petroleumsteknologi NTNU
* Norwegian Radiation Protection Authority (Bjørn Johnsen, Terje Christensen)
* Department of Biology, Dag Hessen, University of Oslo
* Norwegian Institutte for Air Research, University of Oslo, (A.Kylling, G.Braathen)
* Tambartun National Resource Center for the Visually Handicapped, Melhus (P.Fosse)
* Institute for Energy Technology, Kjeller, (B.Hauback, K.D.Knudsen, A.Skjeltorp, P.G.Helgesen, H.Brinks)
* SINTEF (C.Marioara, S.Andersen, J.Walmsley, R. Mathiesen)
* Centre for Viking and Medieval Studies, University of Oslo

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
* Institute of Reservoir Technology and Applied Geophysics, NTNU
* Centre for Biology of Memory, Centre of Excellence, NTNU (E. Moser)
* Institute of neuroscience, St. Olav Hospital Norsk Lysteknisk komité
* Trondheim Science Centre
* Inst. for bioteknologi, NTNU (B.E. Christensen, K.M. Vårum, G.S.B. Bræk, S. Valla, O. Smidsrød, K.I. Draget)
* Inst. for kreftforskning, NTNU: (T. Espevik, A. Sundan)
* Institutt for petroleumsteknologi, NTNU
* Materialteknologi, NTNU, (K.Marthinsen, M.-A. Einarsrud og T.Grande, O.Lohne)
* Institutt for elektronikk og telekom-munikasjon, NTNU (T.Tybell, J.K. Grepstad)
* SINTEF Energiforskning
* Institutt for Kjemisk prosessteknologi NTNU (Z. Yu, Chen, A. Holmen)

EDUCATION

SUBJECTS AND STUDENT ATTENDANCE

Some subjects were self-study courses in 2004

Subjects	*Student Attendance*
M.Sc. Technology 1st and 2nd year.	
Physics for Civil and Environmental Engineering	153
Physics for Geology and Petroleum (incl. lab)	89
Physics for Electronics and Cybernetics	162
Physics for Chemistry and Material Technology (incl. lab)	97
Physics for Informatics and Communication Technology	238
Physics for Machine Technology (incl. lab)	143
Physics for Marine (incl. lab)	76
Mechanical Physics (incl. lab)	134
Electromagnetism (incl. lab)	128
Wave Physics (incl. lab)	110
Thermal Physics (incl. lab)	123
Physics for Energy and Environmental (incl. lab)	134
Chemical Physics and Quantum Mechanics	129
M.Sc. Technology 3rd year.	
Physics 2 for Electronics	69
Electronics (incl. lab)	85
Instrumentation (incl. lab)	66
Statistical Physics	74
Electromagnetic Theory	68
Atomic and Molecular Physics	79
Optics (incl. lab)	59
Quantum Mechanics	58
Cell Biology 1 (incl. lab)	38
Atmospheric Physics (incl. lab)	8
Material Physics and Characterization (incl. lab)	28
M.Sc. Technology 4th year.	
Solid State Physics (incl. lab)	39
Energy and Environmental Physics	20
Non-linear Dynamics	16
Optics, Advanced Course (incl. lab)	16
Applied Quantum Mechanics	33
Solid State Physics, Advanced Course	24
Theory of Classical Fields	25
Molecular Biophysics (incl. lab)	18
Biophysics (special)	27
Classical Transport Theory	8
Signal Processing incl. lab	20
Subatomic Physics	14
Medical Physics (incl. lab)	35
Nuclear and Radiation Physics (incl. lab)	50
Particle Physics	20
Physics of Materials (incl. lab)	9
Computational Physics	8
Experts in Team, Interdisciplinary Project	60

M.Sc. Technology 5th year.

Biophysical Micromethods (incl. lab)	6
Biophysics, Specialization	23
Physics, Specialization	47

B.Sc.

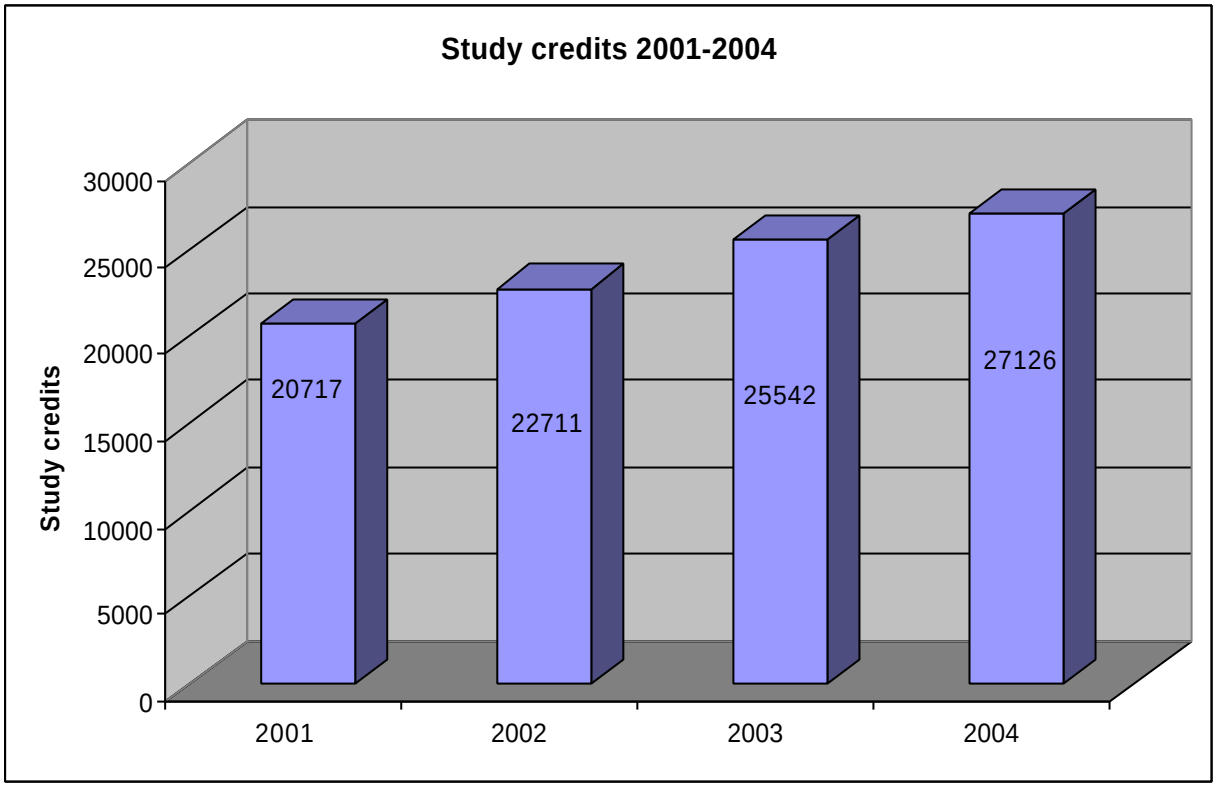
User Course in Physics (incl. lab)	30
General Physics I (incl. lab)	90
General Physics II (incl. lab)	27
Thermal Physics (incl.lab)	13
Electricity and Magnetism (incl. lab)	52
Quantum Physics and Statistical Physics (incl. lab)	33
Mechanics	4
Dynamics	2
Energy and Environmental Physics (incl. lab)	12
Biophysics I (incl. lab)	10
Introduction to Quantum Mechanics	16
Space Technology I	36
Astrophysics	65

M.Sc.

Didactics in Physics (incl. lab)	3
Measuring Sensors and Transducers (incl. lab)	3
Signal Analysis (incl. lab)	3
Optics (incl. lab)	4
Atmospheric Physics (incl. lab)	8
Particle Physics	4
Relativistic Quantum Mechanics	8
Light, vision, color (incl. lab)	5
Energy Resources	17
Space Technology II	8
Quantum Field theory	3
Solid State Physics	5
Functional Materials	4
Biophysics II (incl. lab)	6

PhD.

Characterisation of Solid Surfaces	13
Critical Phenomena	4
Advanced Statistical Physics	4
Interactions of Ionizering Radiation with Matter	3
Electron Microscopy and Diffraction	1
Quantum Theory of Solids	10
Mathematical Approximation Methods in Physics	11
Functional Integral Methods in Condensed Matter	1
Magnetic Resonance Imaging	2
Biooptics and Photobiophysics	2
Technical Optics	6


Study credits 2001-2004
Study credits
30000
25000
20000
15000
10000
5000
0
20717
22711
25542
27126
2001
2002
2003
2004

THESES - GRADUATE STUDIES

Master of Technology/Siv.ing.

Andresen, Christian Andre: *Emittance studies and measurements on CERN's heavy ion source.*
Supervisor: Alex Hansen

Ausland, Line: *Characterization of the positional changes of structures in the lungs between full expiration and full inspiration: A study based on CT images.*
Supervisor: Arne Skretting

Blindheim, Sandra: *Optical reflectance spectroscopy of skin hematomas.*
Supervisor: Anne Borg

Brekka, Ståle: *The ICT-classroom.*
Supervisor: Per Morten Kind

Byberg, David: *Dosimetry of oblique clinical electron beams.*
Supervisor: Tore Lindmo

Dahl, Eskil Kulseth: *Compact Chern-Simons theory.*
Supervisor: Asle Sudbø

Danstorp, Camilla: *Development of methods for coregistration of the lung region in CT image series acquired before and after external radiation therapy.*
Supervisor: Arne Skretting

Fagerholt, Egil: *Accurate measurements of out-of-plane deformations using structured light and close-range photogrammetry.*
Supervisor: Hans Magne Pedersen

Fjeldberg, Egil: *Atomistic modelling of precipitates In Al-Mg-Si alloys.*
Supervisor: Randi Holmestad

Fonnum, Helge: *A low coherence microscope.*
Supervisor: Hans Magne Pedersen

Hallsteinsen, Svein: *Nanoscale lithography of $SrRuO_3$ using an STM.*
Supervisor: Anne Borg

Hals, Monica: *Study of genetic markers in the HLA-class 1 region in multiple sclerosis.*
Supervisor: Catharina Davies

Hansen, Robert: *The effect of the enzymes collagenase and hyaluronidase on transient perfusion in tumour tissue.*
Supervisor: Catharina Davies

Havik, Victor Hegerland: *Geometry of entangled states in quantum mechanics.*
Supervisor: Jan Myrheim

Hergum, Torbjørn: *Parallel Beamforming in 3D Ultrasound using Synthetic Transmit Beams.*
Supervisor: Catharina Davies

Husby, Ellen Marie: *The effect of the enzymes hyaluronidase and collagenase on diffusion and uptake of macromolecules in multicellular spheroids.*
Supervisor: Catharina Davies

Høyland, Vivian: *Caracterisation of the pumping function of the right and left heart ventricles.*
Supervisor: Arne Skretting

Jensen, Kristin: *Aberration in ultrasound imaging.*
Supervisor: Tore Lindmo

Jensen, Line Rørstad: *Breast cancer heterogeneity studied by HR MAS NMR spectroscopy and principal component analysis.*
Supervisor: Tore Lindmo

Johansen, Marie: *The use of IMRT to improce radiation therapy of cancer cercicis uteri –A feasibility study..*
Supervisor: Tore Lindmo

Lervåg, Christoffer: *Characterization of an amorphous silicon electronic portal imaging device.*
Supervisor: Tore Lindmo

Lund, Martin Wold: *Finite approximations to quantum mechanics.*
Supervisor: Johan Skule Høye

Martinussen, Hanne: *NMR-investigations of water distribution in porous media for plant growth in weightlessness.*
Supervisor: Anders Johnsson.

Mathisen, Anders Nedregård: *Study of extreme wind conditions.*
Supervisor: Jørgen Løvseth

Melås, Elin Anita: *Radiation and growth related changes on blood flow and extracellular volume fraction in humane melanoma xenografts measured by dynamic contrast-enhanced magnetic resonance imaging.*
Supervisor: Einar Rofstad

Mjøen, Kristian: *Conveying the Competences of Science Graduates – Exploring the Match between Corporate Expectations and the Competences of Science Graduates.*
Supervisor: Per Morten Kind

Moltumyr, Rune: *Dissolved oxygen transport through tfc.membrane.*
Supervisor: Berit Kjeldstad

Myhr, Geir Ove: *Measures of entanglement in quantum mechanics.*
Supervisor: Jan Myrheim.

Nguyen, Toan Thai: *Fibres of semiconducting polymers made by electrospinning.*
Supervisor: Emil J.Samuelsen

Nygaard, Kirsten: *Dose distributions below bolus edges during electron irradiation from a clinical linear accelerator*.
Supervisor: Tore Lindmo

Off, Morten Kristian: *Aspects of the photobiophysics of folate in solutions and in human skin*.
Supervisor: Thor Bernt Melø

Oksefjell, Hilde: *Quantification of geometric deviation in the planning- and treatment process of radiotherapy*.
Supervisor: Tore Lindmo

Paulsen, Eirik: *Thermo-optical properties of human blood and bovine liver*.
Supervisor: Anne Borg

Refsum, Helge Haakon: *Design, Simulation and Testing of a 2D Electron Sourse Based Calibrating System for a Proton Beam Ionisation Profile. Monitor*. Supervisor: Alex Hansen

Reitan, Nina Kristine: *Quantification of metabolites in intact breast cancer tissue – analysis using spin echo HR MAS spectroscopy*.
Supervisor Tore Lindmo

Rønning, Liv Marit: *Fluctuations on blood flow in tumor tissue studied by dynamic contrastenhanced magnetic resonance imaging*
Supervisor: Einar Rofstad

Schnell, Edrun Andrea: *Effect of the interstitial fluid pressure on fluctuations in oxygen tension in human melanoma xenografts.*
Supervisor: Einar Rofstad

Simonsen, Morten: *Comparative study of characterisation of anodic pretreatment layers on Aluminium surfaces.*
Supervisor: Randi Holmestad

Sjelbred, Hans Ivar: *Design and implementation of database and user interface for energy servicesystem optimization tool.*
Supervisor: Alex Hansen

Skorve, Natalie: *Intracavitary brachytherapy of cervical cancer at St.Olav sHospital.*
Supervisor: Tore Lindmo.

Slyngstad, Kari Elisabeth: *MR-assessment of tumor vascularity – implementation and testing of processing tools –*
Supervisor: Catharina Davies

Soleim, Bjørn Gunnar: *STEM characterisation of perovskite thin films.*
Supervisor: Randi Holmestad

Stabo-Eeg, Franz: *Phase and polarization characterization of a twisted nematic spatial light modulator.*
Supervisor: Mikael Lindgren

Sundsøy, Pål Roe: *Depolarization of orthogonal states of polarization in fiberoptic high-speed transmission*.
Supervisor: Ola Hunderi

Sæther, Hilde Kjernlie: *Finger dosimetry with TL-dosimeters.*
Supervisor: Tor Wøhni

Sæther, Lars Eric: *Fibre-optic detection of physiological parameters employing responsive polymer gels.*
Supervisor: Bjørn Torger Stokke

Tollefsen, Henrik: *Entanglement of indistinguishable particles.*
Supervisor: Jan Myrheim

Tømmerås, Veronica Kristine: *Verification of modulated radiation fields.*
Supervisor: Tore Lindmo

Vollen, Marianne Wivesoll: *Application of vibration based shearography techniques for damage detection in sanwich panels.*
Supervisor: Ole Johan Løkberg

Walle, Lars Erik: *Numerical identification of Kosterlitz-Thouless phase transition from 4th order charge correlations in a logarithmic plasma.*
Supervisor: Asle Sudbø

Wasbø, Ellen: *Testing of the Fricke-gelatin MRI dosimeter and implementation of tools for dose verification.*
Supervisor: Tore Lindmo

Winnem, Andeas Meyer: *Numerical methods for simulation of light transport in skin.*
Supervisor: Anne Borg

Cand.Scient.:

Bø, Gudrun Maria Vetleseter:
Divergensfri kvanteelektrodynamikk.
Supervisor: Kjell Mork

Dokka, Inga Hanne:
Salmer fra fysikklaboratoriet.
Supervisor: Per Morten Kind

Helander, Linda:
ALA-PDT på Jurkat-celler. En studie av lysdose- og osmoseeffekter ved bruk av flowcytometri, lysspektroskopi og MAS-NMR .
Supervisor: Anders Johnsson

Larsen, Hogne Nersund:
Analyse av korrelasjoner i vindfeltet
Supervisor: Jørgen Løvseth

Nordskag, Janniche Iren:
Variasjonsberegninger av energien i grunntil-standen og beregninger av magnetiske egenskaper for flytende helium, ved bruk av LOCV-metoden
Supervisor: Ingjald Øverbø

Thunestvedt, Rune Harald:
Vitenskapeleg argumentasjon i fysikkundervisninga. Et utviklingsprosjekt i 2FY.
Supervisor: Per Morten Kind

Master of Science

Asfaw, Solomon Abebe:
Porphyrin fluorescence from propionibacteria treated with 5-ALA
and 5-ALA methyl ester.
A study of the effects of extracellular ph.
Supervisor: Anders Johnsson

Dorgbadzi, William:
Renewable energy system for Ghana and the potential for concentrating solar electricity generation.
Supervisor: Jørgen Løvseth

Gedamu, Dawit Minale:
Investigation of Polarization changing optica components.
Supervisor: Mikael Lindgren

Jim, Mundy Obilor:
Analysis of time series: An FFT and wavelet analysis of biological and geophysical data.
Supervisor: Anders Johnsson

Tucho, Wakshum Mekonnen;
The effects of SIC and Si3Ny inclusions in multicrystalline silicon solar cell performance.
Supervisor: Randi Holmestad

THESES-DOCTORAL STUDIES

Andrei, Carmen:
Electron Microscopy Studies of Materials used for Hydrogen Storage.
Supervisor: Randi Holmestad

Danielsen, Signe:
Chitosan mediated DNA condensation as a basis for genedelivery: Influence of polyelectrolyte molecular parameters on the condensation behaviour.
Supervisor: Bjørn T.Stokke

Haugen, Nils Erland Leinebø:
Energy spectra and scaling relations in numerical turbulence with laboratory and astrophysical applications.
Supervisor: Alex Hansen

Maurstad, Gjertrud:
Polyelectrolyte complexes and multilayers assembled from biopolymers: Electrostatically driven formation of mesoscale structures.
Supervisor: Bjørn Torger Stokke

Meisler, Terje:
Lepton flavour violation in minimal supersymmetric extension to the Standard model.
Supervisor: Kjell Mork

Næss, Stine:
Nanoparticles in dilute solution: Theory and experiments.
Supervisor: Arnljot Elgesæter

Risa, Øystein:
Application of High-Resolution NMR Spectroscopy in Metablic Studies of the eye.
Supervisor: Anna Midelfart

Thisted, Ulrik Schou:
Magnetic and thermodynamic properties of layered and thin film superconductors.
Supervisor: Kristian Fossheim

ACTIVITIES TO PROMOTE ”PHYSICS”

PRESENTATIONS THROUGH MEDIA

Falnes, J.; Intervju publisert 22.04.2002, 1019411498.48 i nettavisa www.forskning.no

Falnes, J.; Intervju publisert 01.11.2004 1098707791.44 i nettavisa www.forskning.no

Fossheim, K.; *Den einsame bølgja*. Adressavisen 2004, 11.12.2004

Fossheim, K.; *Fins det klokker som måler tid bakover?* Adressavisen 2004, 30.10.2004

Fossheim, K.; *Mikrobølgjeovnen*. Adresseavisen 2004, 25.09.2004

Holmestad, R.; Helvoort, T.V.; *Nytt elektronmikroskop på Instituttfor fysik*, 5 min. innslag på nyheter TV3/TVTrøndelag 07.06.2004

Holmestad, R.; *Nytt TEM på fysikk*, Intervju i Radioadressa 07.06.2004

Jacobsen, E.E.; Kvittingen, L.; Ljones, K.; Lykknes, A.; Wittje, R.; Kjøsen, H.; *Dadler goniometer og fuksin*. Glimt fra NTHs kjemihistorie, Utstilling ved Realfagbiblioteket, NTNU, Trondheim, 01.11. – 29.12 2004

Johnsson, Anders Carl G: *F*ysikkens år - 2005. Adresseavisen 2004

Mo, F.; *Krystallografi – til glede og nytte*, DKNVS Forhandlinger 2003, s. 101-107, with Summary in English, 2004

Ramstad, Ståle: *Er elektromagnetisme helsefarlig?* Radioforedrag i NRKs P2-akademiet. 27. mai 2004.

Samuelsen, Emil J.; *Ord og uttrykk* i ”Menneske og miljø i Nord-Troms, Nord-Troms Historielag, Årbok 2004, Birtavarre, s. 102-103

Sudbø, Asle, *Banebrytende hydrogen-oppdagelse*. Universitetsavisa, NTNU 07.11.2004

Sudbø, Asle, *Fysikk-sensasjon fra NTNU forskere*. Adresseavisa 10.11.2004

Sudbø, Asle, *Megafart med nanoteknologi.* Bladet Forskning, Norges Forskningsråd 25.09.2004

PARTICIPATION IN EVALUATION COMMITTEES

Evaluation committee work

Borg, A.:
* Evaluation of three candidates for position in Physical Electronics, NTNU
* Member evaluation group on “Condensed matter physics in Sweden”, The Swedish Research Council

Falnes, J.:
* Opponent for ei licentiatavhandling , Uppsala universitet 10.12.

Johnsson, A.:
* Member evaluation commitee UiO
* Sensor hovudfageksamen NLH
* Sensor hovudfagseksamen 2 candidates, HS

Kjeldstad, B.:
* Opponent for Norsang Gelson, Department of Physics, University og Bergen.
* Member of evaluation committee for PhD Barbara Schallhart, University of Innsbruck, Austria.

Lindgren, M.:
* Opponent at Tekn Lic Thesis; Kungliga Tekniska Høgskolan, Stockholm (Anna Fagerman; Dept of Laser Physics)
* Supervisor for PhD-student Emil Hællstig, AIM Graduate School, Uppsala University

Samuelsen, E. J.:
* Evaluation member and administrator, dr. ing. dissertation Rune Holmstad, Chem. Eng. NTNU
* Evaluation of candidates for permanent position at the ESRF, October

Worren, T.:
***** Member evaluation committee dr. ing.-dissertation Espen Selvig, NTNU
* Sensor hovudfagseksamen UiO

Arrangements

Borg, A.:
* Co-chair of the 5th Nordic-Baltic Scanning Probe Microscopy Workshop, June 16-19th 2004, Realfagsbygget, Trondheim

Davies, C.:
* Convenor of "Fredagskollokviet I fysikk", spring 2004

Fossheim, K:
* Convenor of "Fredagskollokviet I fysikk", spring and autumn 2004

Mo, F.:
* Organiser SNBL Workshop, 21-22 June 2004, Trondheim

Stokke, B.T.:
* Co-chair of the 5th Nordic-Baltic Scanning Probe Microscopy Workshop, June 16-19th 2004, Realfagsbygget, Trondheim

Worren, T.:
* Member of the local committee for the 5th Nordic-Baltic Scanning Probe Microscopy Workshop, June 16-19th 2004, Realfagsbygget, Trondheim

PARTICIPATION IN NATIONAL, INTERNATIONAL, UNIVERSITY AND DEPARTMENTAL COMMITTEES

International commissions:

Borg, A.:
* Member of the steering committee of the ESF Scientific Program “Nanotribology (NATRIBO)”
* Member of “Beredningsgrupp før kondenserade materiens fysik” The Swedish Research Council
* Member of IUPAP Working Group on Women in Physics

Fossheim, K.:
* Member, Steering Committee Vortex Matter Programme under ESF

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).

Holmestad, R.:
* Norwegian representative board member in Scandinavian Electron Microscopy Socity SCANDEM

Hunderi, O.:
* Topical Editor, Journal of the Optical Society of America
* Editorial Board, New Journal of Physics

Johnsson, A.:
* Consultant, Italian Space Research Council

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

Lindgren, M .;
* Member of the innovation council (Innovationsrådet) at FOI, Sweden.

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

Mork, K.:
* Editor, Physica Scripta

Naqvi, K.R.
* Member, International Union of Pure and Applied Chemistry Task Group for updating and expanding "Glossary of Terms used in Photochemistry"

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

Valberg, A.:
* Norwegian representative in Division I (Vision and Colour), Commission Internationale d’lEclairage (CIE)
* Member of CIE technical committee TC1-59, CIE 10 degree Photopic Photometric Observer
* Member of CIE technical committee TC1-36, A Physiologically Based System for Colour Measurements.

National commissions:

Borg, A.:
* President, Norwegian Physical Society
* Member of the "National committee on World Year of Physics 2005"

Brataas, A.:
* Member in council of the planned network of excellence in EU 6th programme "Fundamentals of nanoelectronics"

Hansen, A.:
* Member of Working Group on Nano Technology, Norwegian Research Council.

Hemmer, P.C.:
* Member, board of Vista
***** Member (representing NTNU), board of Nansenfond.

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

Johnsson, A.:
* Member board of Teknologi i grunnopplæring i skolen, TIGRIS
* Member of board of Forum for kunnskapshistorie

Kjeldstad, B.:
* Member, board of KLIMAPRO, Programme for climate research in Norway, The Norwegian Research Council
* Educational committee for geophysical courses at University Studies of Svalbard
* Substiute member, Board of University of Svalbard
* Substiute member, Board of Sør-Trøndelag University College, Faculty of Technloly

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

Olaussen, K.:
* Member of "Fordelingsutvalget for tungregning" The Norwegian Research Council.

Stokke, B.:
* Member of UHR, Nasjonalt råd for teknologisk utdanning
*Member, representing NTNU in the board of FUNMAT.
* Chairman, board of council in NORLIGHT

Sudbø, A.:
*Chairman, Norsk fysikkråd
* Member, NORDITA Committee on Condensed Matter Physics/Biophysics.

Valberg, A.:
* Member of the committee for Science and Development at Tambartun National Center for the Visually Handicapped
* Member of board of NTNU University Programme for Master Studies in Neuroscience

University and Departmental commissions:

Borg, A.:
* Committee member, Engineering studies at NTNU
***** Chairman of Educational Committee, Department of Physics, NTNU

Davies de Lange, C.:
* Chairman of Division of Biophysics and Medical Technology

Hansen, A.:
* Vice Department Head, Department of Physics, NTNU

Hunderi, O.:
* Member of the Board, Department of Physics, NTNU
* Chairman, Study Programme for Physics and Mathematics.

Johnsson, A.:
* Head, Department of Physics, NTNU
* Chairman, board of Museum of Natural History and Archaeology, (Vitenskapsmuseet), NTNU

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

Olaussen, K.:
* Chairman of Division of theoretical Physics,

Samuelsen, E. J.:
* Chairman of Division of Condensed Matter

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

Stefansson, T.:
* Member, board of steering committee, School Laboratory for Mathematics, Natural Sciences and technology, NTNU

Stokke, B.:
* Vice Dean at Faculty of Science and Technology
* Chairman of faculty education committee
* Chairman, committee for "Nanotechnology", NTNU
* Member, board of committee for Medical Technology at NTNU
* Substitute member, Board - Programme for Education of Teachers, NTNU
* Member, committee for new degree structure (UNG), NTNU
* Project Director, Thematic Area Materials at NTNU

FRIDAY AFTERNOON LECTURES

"Fredagskollokviet i fysikk"
Convenors: Catharina Davies and Kristian Fossheim

Programme - spring term

16.01 Asle Sudbø, Inst for fysikk, NTNU: *Physics from a different world: The Nobel Prize in Physics 2003*

23.01 Jørgen Nyhus, Binor: *Arbeidet med utvikling av norsk medisin mot HIV og AIDS*

30.01 Reidar Stølevik, Inst for kjemi, NTNU: *Elektronbølger - mennesker - molekyler*

6.02 Iver Brevik, Inst for energi- og prosess-teknikk, NTNU: *Casimireffekten: teori og eksperiment.*

13.02 Suzanne McEnroe, Norges Geologiske undersøkelse, Trondheim: *From Rogaland to Mars: Nanoscale features in minerals that remember*

20.02 Norvald Nesse, Inst for kjemisk prosessteknologi, NTNU: *Saltkraft, - ny "grønn" energi*

27.02 Ragnvald Mathiesen, SINTEF Materialteknologi: *In-situ stuides of solidfication microstructures and phenomena in eutectic alloys*

05.03 Arne Smalås, Inst for kjemi, Univ. i Tromsø: *Strukturbiologi i en postgenom tid*

12.03 Ole Harbitz, Statens Strålevern: *Radioaktivitet i marine miljø*

19.03 Olav Haraldseth, Institutt for sirkulasjon og bildediagnostikk, NTNU: *Nobelprisen i medisin 2003 - Magnetisk resonans avbilding*

26.03 Jochen Mannhart, Univ. i Augsburg: *Superconducting p-Electronics*

16.04 Jørgen Peder Steffensen, Niels Bohr Instituttet, København: *Det 20. århundredes globale opvarmning: Ser vi tingene i det rette perspektiv?*

23.04 Iver Brevik, Inst for energi- og prosessteknikk, NTNU: *Big Bang teorien: Hvor mye forstår vi av universets skapelse?*

30.04 Lisa Lorentzen, Inst for matematiske fag, NTNU: *Store fags pedagikk*

07.05 Gaute Einevoll, professor i fysikk ved Institutt for matematiske realfag og teknologi, Norges landbrukshøgskole. *Physics in the Brain*

Programme – autumn term

27.08: Professor Bengt Kasemo, Chalmers: Biointerfaces

03.09: Professor Johan Høye, Fysikk, NTNU: *Tilfeldig gang og termiske egenskaper til polymere.*

10.09: Professor Stig Berge, NTNU: *Sammenbrudd i kompositttstrukturer. En detektivhistorie fra oljeutvinningen i Nordsjøen.*

17.09: Professor Alex Hansen, Fysikk, NTNU: *Optimal Paths in Physics.*

24.09: Førsteamanuensis Anna Lipniacka, Universitetet i Bergen: *Tema fra eksperimentell høyenergifysikk.*

01.10: Professor Bjørn Pedersen, Elektro, NTNU: *NCUBUS- Norges første satellitt.*

08.10: Førsteamanuensis Oddvin Herstad, Kjemi, NTNU: *Kvikksølvamalgam: Nervegift eller inert tannfyllingsmateriale?*

15.10: Professor Tor Grande, Kjemi, NTNU: *Materialer i kjemisk potensialgradient - en utfordring for høy temperatur elektokjemiske celler.*

22.10: Professor Kåre Olaussen, Fysikk, NTNU: *Nobel-prisen i fysikk 2004. Hva er "asymptotic freedom"?*

29.10: Førsteamanuensis Carl Henrik Waadeland, NTNU: *Musikk/fysikk/matematikk*

05.11: Professor Asle Sudbø, Fysikk, NTNU: *New quantum liquids.*

12.11: Professor Bjørgvin Hjørvarsson, Universitetet i Uppsala:: *Dimensional games in solid state physics.*

19.11: Professor Daniel Bonn, Ecole Normale Supérieure, Paris: *Avalanch behavior in yield stress fluids.*

26.11: Førsteamanuensis Thomas Tybell, Elektro, NTNU: *Ferroelectricity: Challenges and Possibilities*

03.12: Forsker Dag Breiby, Risø: *Novel Applications of X-rays in Materials Science*

10.12: Professor Gaute Einevoll, NLH: *Om livets opprinnelse*