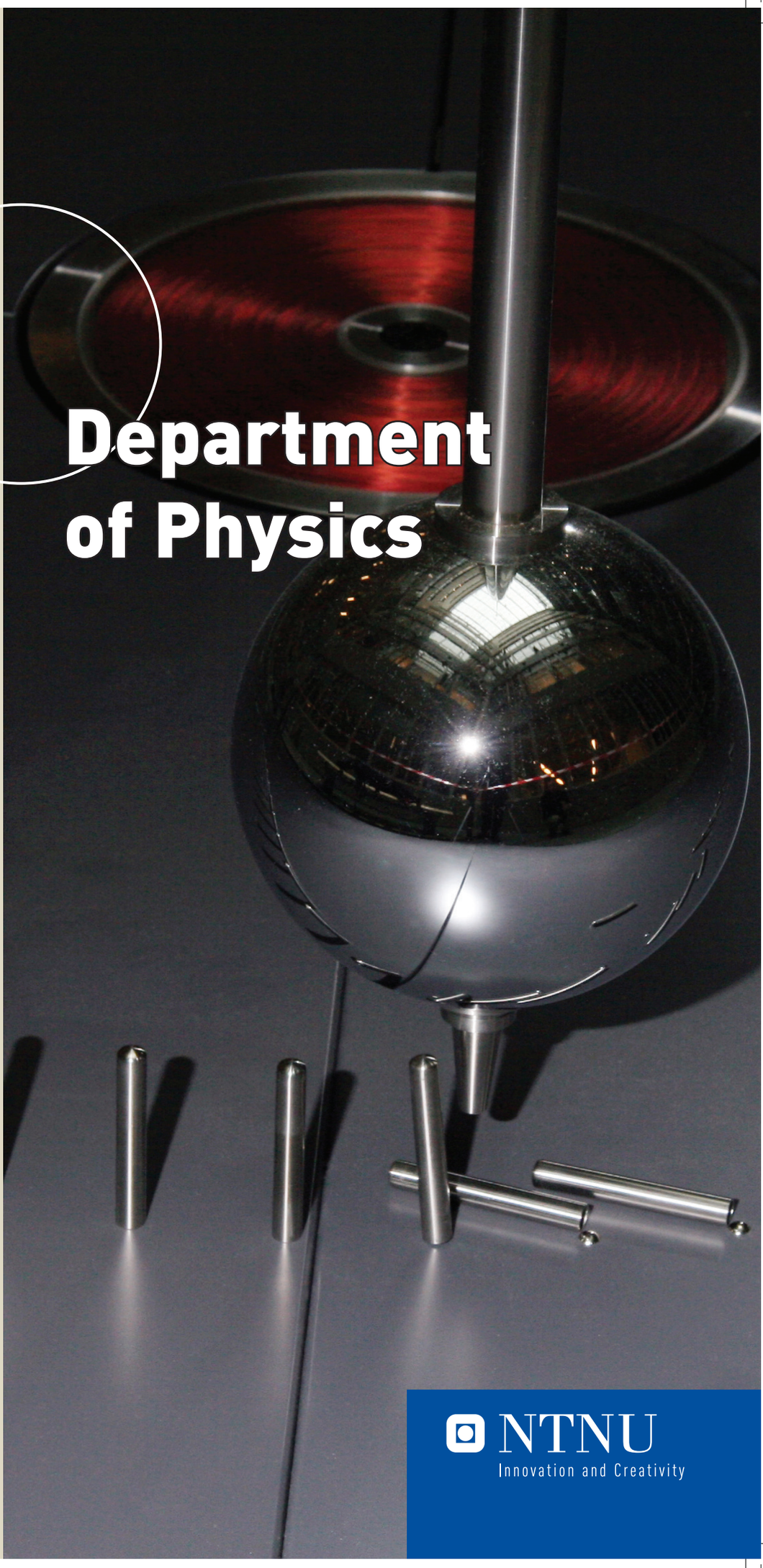
Department of Physics

Annual Report 2007



NTNU
Innovation and Creativity

DEPARTMENT OF PHYSICS, NTNU

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Head of Department:	Professor Berit J. Kjeldstad
Deputy Head of Department:	Professor Kåre Olaussen
Head of Administration:	Cand.scient Sylvi Vefsnmo

Departmental Council

Elected members:

Representing the permanent scientific staff	Professor Randi Holmestad
	Professor Catharina Davies
	Professor Alex Hansen
	Professor Mikael Lindgren
Representing the temporary scientific staff	Doctoral Student Eirik Glimsdal
Representing the technical/administrative staff	Head Engineer Oddbjørn Grandum
Representing the students of the department	Student Janne Pedersen
Appointed external member:	Research Manager Jostein Mårdalen (chair), SINTEF Petroleum Research
	Professor Lisa Lorentzen, NTNU, Department of Mathematical Sciences

COVER PAGE

Foucault's pendulum
NTNU has installed a Foucault's pendulum in Realfagbygget.
Foucault's pendulum has its name from the physicist Léon Foucault's famous demonstration in Paris in 1851.
This is still the easiest and most visual proof of the earth's rotation.

Photo: Mentz Indergaard / NTNU Info

DEPARTMENT OF PHYSICS, NTNU

http://www.ntnu.no/fysikk

CONTENTS

THE DEPARTMENT OF PHYSICS.....page 3
- A Glance at 2007
- Staff
- Accounts
- Awards
- Special Events

RESEARCH .....page 10
- Division of Applied Physics and Didactic Physics
- Division of Biophysics and Medical Technology
- Division of Complex Materials
- Division of Condensed Matter Physics
- Division of Theoretical Physics
- Publications
- Books and Book Chapters
- Reports
- Conferences and Talks
- Physics Presentations through Media
- Cooperating Institutions

EDUCATION.....page 50
- Subjects and Student Attendance
- Theses - Graduate Studies
- Theses - Doctoral Studies

PARTICIPATION IN COMMITTEES .....page 58
- Evaluation Committees, International Committees, National Committees, University and Departmental, Arrangement Committees

FRIDAY COLLOQUIUM .....page 62

Edited by:
Eli Monsøy, Arne Mikkelsen, Sylvi Vefsnmo og Berit Kjeldstad

The Annual report is also available on the internet address:
http://www.ntnu.no/fysikk/arsrapporter

A GLANCE AT 2007

With a total 165 staff, the Department of Physics is one of the largest departments in NTNU. In 2007 the department completed its strategic plan. Its mission "to provide an attractive and internationally acclaimed environment for those pursuing physics as students and researchers" is in keeping with the guiding vision of NTNU: “NTNU Internationally Outstanding 2020”

The main research profile of the department lies within the strategic areas of NTNU, which are:

- Energy and petroleum, resources and environment
- Information and communication technology
- Materials technology
- Medical technology

In addition nanotechnology and computational physics are important elements in our new strategic plan.

One of our main goals is to lift the level of external funding, and to increase, without lowering the quality, the number of scientific publications. The external funding, which comes mainly from the Research Council of Norway, constitutes 39 % of the total activity. The year 2007 was propitious in that several new projects were initiated. The scientific production per academic staff/postdoc has never been larger. The Department of Physics was among the 50 most productive institutes in the country, and the most productive among physics departments this year. Taking into account the heavy teaching load of our faculty, with altogether 24659 study points produced in 2007, this is a good attainment. The initiation of new projects is expected to help maintain, or even raise, the research output during the coming years.

Study programs in physics are popular among students. Despite the declining interest for natural sciences among the young, interest in physics has not waned, and enrolment of good students remains satisfactory. PhD positions at the department are keenly contested and there are several good applicants for each vacancy.

The department is going through a phase of new recruitment; three new professors (P. Espy, I. Simonsen and I. Sorokina) and two new associate professors (D. Breiby and T. van Helvoort) were appointed in 2007. In addition two new associate professorships will be established when researcher (R. Mathiesen) and postdoc (M. Sletmoen) finish their projects in 2010 and 2009, respectively. The appointment of seven new faculty members will strengthen the strategic areas within the department and infuse new activity. The demands on new infrastructure are a natural consequence of this. The department is heavily involved in the establishment of NTNU’s nanolab. New laboratories in optics, X-ray and 3rd generation solar cells research are under development. At the same time three professors (E. Samuelsen, E. Hiis Hauge and F. Mo) have re-tired, and each has become an emeritus professor.

Three members of the staff received awards for their work within research and teaching. Professor Alex Hansen received The Birkeland prize, postdoc Marit Sletmoen the Prize for Young Researchers in Science and Associate professor Jon Andreas Støvneng the prize for pedagogy. For further details see page 6 in the report.

This year the last project established during Year of Physics in 2005 was completed when the new Foucault pendulum was opened to public in Realfagbygget.

Berit Kjeldstad
Head of Department

STAFF

Head of Department:
Professor Berit Kjeldstad

Deputy Head of Department:
Professor Kåre Olaussen

PERMANENT STAFF

SCIENTIFIC STAFF:

Professors
Jens O. Andersen, Anne Borg, Arne Brataas, Catharina Davies, Arnljot Elgsæter, Patrick Espy, Jon Otto Fossum, Alex Hansen, Eivind Hiis Hauge, Randi Holmestad, Ola Hunderi, Johan S. Høye, Anders Johnsson, Michael Kachelriess, Berit Kjeldstad, Mikael Lindgren, Tore Lindmo, Thor Bernt Melø, Arne Mikkelsen, Frode Mo, Jan Myrheim, Kalbe Razi Naqvi, Kåre Olaussen, Steinar Raaen, Ingve Simonsen, Bo-Sture Skagerstam, Irina Sorokina, Bjørn Torger Stokke, Asle Sudbø, Arne Valberg.

Associate professors
Berit Bungum, Dag W. Breiby, Antonius Helvoort, Morten Kildemo, Tore H. Løvaas, Pawel Sikorski, Knut Arne Strand, Jon A. Støvneng, Erik Wahlstrøm, Turid Worren, Ingjald Øverbø.

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

TECHNICAL AND ADMINISTRATIVE STAFF:

Head of Administration
Sylvi Vefsnmo

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

Technical staff
Irene Aspli, Ole Tore Buset (substitute), Rolf Dahl, Knut R. Gjervan, Oddbjørn Grandum, Tor Jakobsen, Dagfinn Johnsen, Erling Kristiansen, Lise Kvalø, Per Magne Lillebekken, Heimir Magnusson, Arne Moholdt, Jon Ramlo, Inge Sandaunet, Edrun Andrea Schnell, Bjørn Gunnar Soleim (substitute), Bertil O. Staven, Kristin Grendstad Sæterbø.

TEMPORARY STAFF:

Post doc/research scientist
Trine Højberg Andersen, Øyvind Borck, Ahmed Gmira, Daniel Huertas-Hernando, Dionne Klein, Gjertrud Maurstad, Ragnvald Mathiesen, Anh Kiet Nguyen, Steinar Kragset, Stine Nalum Næss, Sverre Vegard Pettersen, Bjørn Skjetne, Marit Sletmoen, Stein Olav Skrøvseth, Pradhan Srutarshi, Mathieu Taillefumier, Ingunn Tufto, Rene Vissers, Per Erik Vullum, Roland Wittje, Yang DeZheng, Bao-xiang Wang, Min Zhou, Xiaofeng Yu.

Doctoral students
Christian Andresen, Asadollah Bagheri, Jan Øystein Haavig Bakke, Binod Kumar Bhattarai, Ruben Bjørge, Håvard Huru Bergene, Kjetil Børkje, Actor Chikukwa, Eskil Kulseth Dahl, Roya Dehghan, Arne Erikson, Tom Richard Evensen, Davi de Miranda Fonseca, Amund Gjerde Gjendem, Jørn Foros, Eirik Glimsdal, Martin S. Grønsleth, Kjetil Magne Dørheim Hals, Henning Frydenlund Hansen, Håvard Haugen, Mari Juel, Lars Kyllingstad, Lars Erlend Leganger, Jacob Rune Linder, Yun Liu, Hanne Mehli, Åsmund Fløystad Monsen, Jan Petter Morten, Florian Mumm, Ingar Stian Nerbø, Kenate Nemera Nigussa, Heidi Nordmark, Magnus Østgård Olderøy, Amutha Ramachandran, Thomas Ramstad, Ole Christen Reistad, Nina Kristine Reitan, Zbigniew Rozynek, Terje Røsten, Magne Saxegaard, Hans Joakim Skadsem, Marius Aase Solberg, Bjarte Gees Bokn Solheim, Frantz Stabo-Eeg, Rune Strandberg, Aksel Straume, Ingeborg-Helene Svenum, Ragnhild Sæterli, Sven Tierney, Sedsel Fretheim Thomassen, Henrik Tollefsen, Malin Torsæter, Wakshum M. Tucho, Glenn Tørå, Asle Heide Vaskinn, Lars Erik Walle.

PROFESSOR EMERITI:

Johannes Falnes, Per C. Hemmer, Kristian Fossheim, Hans Kolbenstvedt, Ole J. Løkberg, Jørgen Løvseth, Kjell Mork, Haakon Olsen, Emil Samuelsen, R. Svein Sigmond, Helge R. Skullerud, Ivar Svare, Sigmund Waldenstrøm.

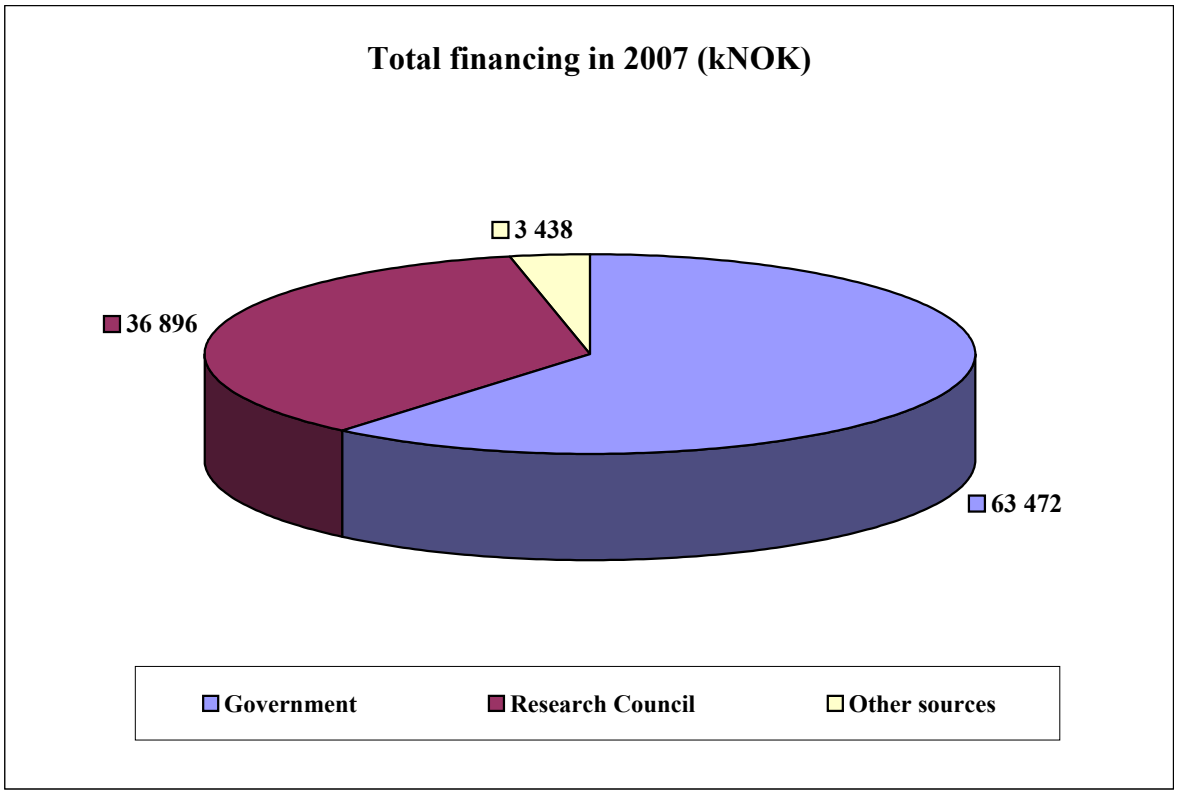
ACCOUNTS 2007

		Amount kNOK
Government University Funding (including NTNU strategy projects)		**63 472**
Projects financed by the Research Council of Norway	**Project manager**	**Amount kNOK**
Nanostructured Soft and Complex Materials	Alex Hansen	4 094
Search for Reliable Signals of Catastrophic Failure	Alex Hansen	646
Stipendiat, H.H.Bergene	Alex Hansen	33
Two-Phase Flow	Alex Hansen	154
Petromax	Alex Hansen	330
Mapping of Residual Oil between Wells	Alex Hansen	456
Role of Bursts in Fracture Front Propagation	Alex Hansen	3
Electromagnetic Fields and Biological Effects	Anders Johnsson	88
Structural, Electronic and Optical Properties of Atomic Overlayers on Surfaces	Anne Borg	207
FUNMAT, Post.doc.	Anne Borg	97
FUNMAT, PhD	Anne Borg	458
Quantum Transport in Nanoscale Systems	Arne Brataas	112
Transport of Spin and Charge in Semiconductors	Arne Brataas	21
Fundamentals of Nanoscale Systems	Arne Brataas	1 227
Fundamentals of Condensed Matter	Arne Brataas	3 461
Quantum Transport in Nanoscale Systems	Asle Sudbø	265
IKT-Oxides	Asle Sudbø	11 996
Factors Controlling UV radiation in Norway	Berit Kjeldstad	356
Material Fluxes from the Russian Rivers Ob and Yenisey	Berit Kjeldstad	53
Polymer Gel Signal Transducers	Bjørn T. Stokke	519
Structure Formations and Properties of Polyelectrolyte Complexes	Bjørn T. Stokke	553
FRIBIOMOL, Activation of Toll-like Receptors	Bjørn T. Stokke	640
Advanced Biological Materials	Bjørn T. Stokke	91
Intravital Microscopy and MRI	Catharina Davies	361
Point Contact Investigations	Erik Wahlstrøm	934
Magnetodynamics of Nanostructured Metal Oxides	Erik Wahlstrøm	9
Småforsk	Several	1 017
Travel Support SNBL/ESRF	Frode Mo	394
Structure Studies og Ferroic Materials under Non-Ambient Conditions	Frode Mo	105
ATEMIC	John Walmsley	538
Structure and Dynamics of Soft and Complex Nanomaterials	Jon Otto Fossum	227
SUP Complex	Jon Otto Fossum	180
IPP, Interconnected Physical Phenomena	Jon Otto Fossum	1 082
European Conference on Neutron Scattering	Kenneth Knudsen	80
Posisjoneringstiltak EUs 7 RP	Kildemo/Lindgren/Nguyen	114
Dendritic Nanoporous Materials with Multifunctionality	Mikael Lindgren	216
Nanoscale Control of Mineral Deposition within Polysaccharide Gel Networks	Pawel Tadeusz Sikorski	92
Micro- and Nanostructure, Materials Development	Randi Holmestad	599
FUNMAT, PhD	Randi Holmestad	349
Studies of the Electronic Structure of Materials at the Nanoscale	Randi Holmestad	1 111
Kimdanningskontroll for Optimaliserte Egenskaper	Randi Holmestad	1 220
Fundamental investigations of Solute Clustering and Nucleation of Precipitation	Randi Holmestad	860
Study of Entanglement and Quantum Information in Condensed Matter Sys.	Stein Olav Skrøvseth	582
Thin-film III-V Semiconductors	Turid Worren Reenaas	105
PhD, Rune Strandberg	Turid Worren Reenaas	565
Nanomaterials for 3rd Generation Solar Cells	Turid Worren Reenaas	296
	Sum	**36 896**

Contribution from other financial sources

Contributors	Project name	Project manager	Amount kNOK
EUs 6 FP:	Dynamax, Dynamic Magnoelectronics	Arne Brataas	766
Statoil:	Prof II, Roger Solli	Anders Johnsson	69
VISTA:	Geometry of fracture networks in reservoirs	Alex Hansen	23
FOI, Totalforsvarets foskningsinstitutt	Sensorskydd	Mikael Lindgren	125
Kreftforeningen:	Transport av terapeutiske makromolekyl i tumorvev	Catharina Davies	140
NUFU:	Renewable Resources	Turid W. Reenaas	607
NUFU:	Solar Energy in Mozabique	Turid W. Reenaas	1 098
NUFU:	Spatial and Seasonal variation in solar radiation	Berit Kjeldstad	255
SINTEF:	Shell Quatar IFT	Knut Arne Strand	60
SINTEF:	SAXS-instrument	Jon Otto Fossum	11
Statens Strålevern:	Prof II, Tor Wøhni	Tor Wøhni	114
Statens Strålevern:	UVnett	Berit Kjeldstad	5
IFE:	Prof II, Kenneth Knudsen	Anders Johnsson	111
Sør-Trøndelag Fylkeskommune:	Kurs for lærere i fysikk	Berit Bungum	18
Other customers		Head of Department	36
		Sum	**3 438**

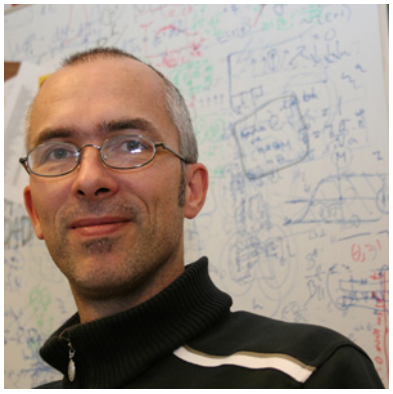
Total external accounts in 2007 **40 334**



AWARDS

During the annual celebration of the Royal Norwegian Society of Sciences and Letters, held on Friday 9th March in the Archbishop's Palace, the Prize for Young Researchers in Science (financed by the I. K. Lykke Fund) was awarded to dr. Marit Sletmoen.

The Birkeland prize (sponsored by Norsk Hydro) for 2007 was awarded to Professor Alex Hansen in recognition of his outstanding research in the area of statistical physics. The prize, awarded biennially, was presented on 10th August during the 2007 meeting of the Norwegian Physical Society held in Tromsø.



At the closing ceremony for this year's Masters in Science and Technology, held on Friday 1st June, Associate professor Jon Andreas Støvneng was awarded the prize for pedagogy at the Faculty of Natural Science and Technology.

SPECIAL EVENTS

In March 2007 a Foucault's pendulum was installed in Realfagbygget

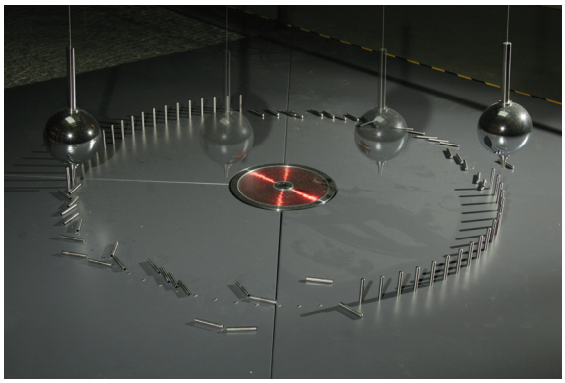
This picture is taken in connection with the official opening of the Foucault's pendulum in Realfagbygget at NTNU. In the background we can see Professor Ola Hunderi, who took the initiative to install the pendulum. (Photo: Arne Asphjell/NTNU Info)

A Foucault's pendulum is found as an ornament and as a demonstration in a number of physics buildings around the world. It has its natural place in Realfagbygget at NTNU. It has a great symbolic value for natural science students and for the university as a whole.

"Have you seen the earth go round? Would you like to see it rotate? Go to the Pantheon on Thursday from ten a.m. to noon. The remarkable experiment devised by M. Léon Foucault is carried out there, in the presence of public under the finest conditions in the world; and the pendulum suspended from the Soufflot's dome clearly reveals to all eyes the rotational movement of our planet". Thus wrote Terrien, the scientific correspondent, on the front page of "Le National" on 26 March 1851.

Foucault's experiment was the first laboratory experiment that clearly demonstrated the rotation of the earth. The experiment is very simple; take a pendulum and let it swing in a plane. You will then see that the plane of oscillation will slowly rotate. In practice it is best to suspend a heavy ball in a long thin wire so that the influence of air resistance and air currents is minimized. The Department of Physics installed a Foucault's pendulum in Realfag-bygget in March 2007. There will always be some air resistance so in order to have the pendulum running continuously, the pendulum is equipped with a magnetic drive to compensate for the energy loss due to air resistance. Foucault used a ball weighing 28 kg in his experiment and the length of the pendulum was 67 m. The length of the NTNU pendulum is 25 m and the weight of the steel ball is 36 kg. This pendulum is thus among the longest pendulums in the world in a university building.

To understand the principle of the pendulum it is simplest to imagine the pendulum mounted on one of the poles, for example the North Pole. The pendulum is an inertial system and the plane of oscillation of the pendulum is fixed. The earth will rotate underneath the pendulum, one full rotation in 24 hours. Seen from the surface of the earth the plane of oscillation of the pendulum will rotate in the opposite direction of the earth's rotation.



A multiexposure picture showing the motion of the pendulum. (Photo: Mentz Indergaard / NTNU Info)

In other locations it is more complicated to understand the motion since the mounting of the pendulum will rotate with the earth, but the main result is that the rotation will be slower than at the poles. If we let the pendulum swing in the east-west direction at the equator, the plane of oscillation is the same as the earth's equatorial plane. This plane does not change when the earth rotates, and the pendulum does not rotate at all. For other locations it can be shown that the number of hours for a full rotation of the plane of oscillation is $24/\sin\beta$, where β is the latitude. Trondheim is at latitude $\beta = 63.4$ degrees north, and the time for rotation is 26 hours and 45 minutes.

RESEARCH

DIVISION OF APPLIED PHYSICS AND DIDACTIC PHYSICS

Staff
Assoc. professor Berit Bungum
Professor Patrick Espy
Assoc. professor Morten Kildemo
Professor Berit Kjeldstad
Professor Mikael Lindgren
Assoc. professor Tore Løvaas
Professor Ingve Simonsen
Professor Irina Sorokina
Assoc. professor Knut Arne Strand
Assoc. professor Turid Worren

Professor emeritus Johannes Falnes
Professor emeritus Ole Johan Løkberg
Assoc. professor emeritus Jørgen Løvseth
Professor emeritus R. Svein Sigmond
Professor emeritus Helge Skullerud

Non-tenured staff
Sverre V. Pettersen (Research scientist)
Dr. Roland Wittje (Postdoc)

Overview

The Division of Applied Physics and Didactic Physics consists of several research teams carrying out research within the fields of *electron and ion physics, energy, atmospheric and environmental physics, applied optics and laser physics,* as well as *physics education ("didactic physics")*.

Study of interfaces between fluid phases existing in oil and gas reservoirs is performed by light scattering (*Strand*). Both model systems and samples from actual gas and oil fields are studied under reservoir conditions (studies can be performed at pressure up to 700 bar and temperature up to 180°C.) The studies are performed with the purpose of improving condensate and oil reservoir management and production.

In electron and ion physics one studies electrical breakdown in fluids and gases (*Løvaas, Sigmond),* breakdown in vacuum related to the Compact Linear Collider (CLIC) at CERN *(Kildemo)*, and transport of ionized gases (*Skullerud)*. The applied optics group (*Lindgren, Kildemo*) carries out studies of photo-physical properties of molecular systems in biology and materials sciences. The optics group also develops optical instrumentation prototypes in polarimetry. Research in the group also involves video holography (*Løkberg*) and optical coherence tomography *(Kildemo, Løkberg*).

In energy and environmental physics the processes affecting transmission of ultraviolet radiation to the surface, particularly the importance of aerosols and clouds, are being studied (*Kjeldstad*), as well as renewable energy sources such as wind and ocean waves *(Falnes, Løvseth*). Research on new solar cell materials is also carried out *(Reenaas)*.

Research in physics education (*Bungum*) involves curriculum development in physics and technology education, in a contemporary as well as in a historical perspective. A PhD study in the group investigates the effects of in-service courses in space technology, in terms of the nature and extent of teachers' realisation of content knowledge gained from the courses in their teaching.

During 2007 three new professors joined the division. Their research will centre around laser physics and related applications *(Sorokina)*, theoretical modelling of optical materials *(Simonsen)*, and on atmospheric research using ground-based and satellite remote sensing *(Espy)*.

For 2007 we have chosen to give a more thorough account of research carried out by our researcher that recently joined the group with interest in optics and laser physics research.

Optics of disordered systems
(I. Simonsen)
In elementary optics classes, we are introduced to the Fresnel formulas that describe the reflection and transmission from perfectly flat surfaces. However, no natural or man-made surface is really flat; they are instead randomly rough (at some scale). This may be one of the reasons for the late Wolfgang Pauli being quoted for saying "Surfaces are made by the devil!" Lord Rayleigh was the first, more than a century ago, to study the wave scattering from rough interfaces. Since then, huge research efforts have been invested into the study of this topic, partly due to its practical applications. Traditionally, surface structure has been looked upon as something that can hardly be avoided. Recently, however, the situation has partly changed, and today man-made surface structures are "engineered" towards application, and this latest development has created renewed interest in the surface scattering problem.

Our research on rough surface scattering has partly been focused on theoretical studies of multiple scattering phenomena and the attendant coherent effects. Given the scattering geometry and the surface topography - or more precisely its statistical properties - one wants to predict the angular distribution of the scattered light. This is called the forward scattering problem. To achieve this, one has in principle to solve Maxwell's equations subject to the appropriate boundary conditions at the

surface. For a surface random system, this is presently too hard a problem in general. It is almost like doing chemistry by always having to solve the Schrödinger equation; it is practically impossible (even with the most powerful computers). As a consequence, much of our research related to this problem has been devoted to finding approximate solutions, judging their quality, and to trying to locate simple geometries where certain optical phenomena can be observed under favorable experimental conditions. One simplification that we have often applied is to study one-dimensional scattering geometries, i.e. scattering systems where the surface roughness is a function of one variable, $x_3 = \zeta(x_1)$, and the incident light is polarized either in, or out of, the incident x_1x_3-plane (i.e. p- or s-polarization). Under these conditions, the scattering problem still shows many of the characteristic features of the general problem. Moreover, it can be formulated by a scalar wave equation -- resulting in dramatic simplifications, particularly for numerical simulations. In this latter case the Maxwell equations can be solved rigorously on a standard personal computer. Some examples of simulation results that can be obtained are depicted in Figure 1.

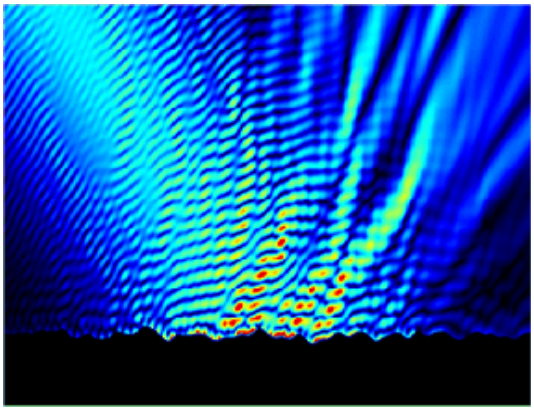


Figure 1: Intensity contour plot of the total electromagnetic field after the incident finite sized beam is scattered from a randomly rough metal surface illuminated at an angle from the left. (Image courtesy of Thomas Berg).

This field of research addresses fundamental science questions e.g. those in emerging fields like plasmonics. Moreover, it has numerous applications e.g. in flat display technology and solar cells.

Mueller matrix ellipsometry in imaging and spectroscopy

(M. Kildemo)

Mueller matrix ellipsometry is developed and used in the laboratory to study the polarization response (retardance, dichroism, depolarization) of colloids, partially ordered (self assembled nanostructures, rough surfaces) and ordered surfaces (e.g. optical gratings). Furthermore, imaging of the polarization response (Mueller matrix) of turbid media, such as biological tissue (like the skin), is currently a hot topic that is being developed. Recent polarimetric images of biopsies of cervical cancer *(Anastasiadou, Paris)* provide an example. In parallel, the important activity of spectroscopic ellipsometry of thin films of unknown structure/texture and composition is pursued (such as commonly obtained from variable process conditions in sputter deposition, PECVD and others).

Instrumentation activity

The group aims at being able to develop research grade proto-types of the state-of the art of optical techniques, particularly related to spectroscopic and laser based methods in polarimetry. The latter involves opto-mechanical design, optical design, instrumentation/acquisition hardware and software in addition to the algorithms for analysis and related software.

Several candidates for Mueller matrix ellipsometry techniques are investigated in the laboratory. The rotating compensator based MME, based on achromatic double Fresnel rhombs appears to be the most promising system for both laser scattering and wide band MME spectroscopy (IR to VUV). A unique research system based on multiple lasers, a full goniometer and a rotating achromatic retarder based MME, has been implemented at the NTNU *(Stabo-Eeg, Kildemo, Lindgren)*.

The liquid crystal based systems have been found to be best suited for MME imaging, visible to NIR. A first prototype, implemented at the NTNU, of a Fe-LC based NIR-MME appears promising as the fastest and most robust (w.r.t. calibration) system. The latter system is currently being implemented into the Mueller matrix imaging mode, and will hopefully be compatible with typical frame-rates of modern CCD cameras.

The general approach pursued in the laboratory also allows development of accurate polarimeters for astronomy, functional imaging in process monitoring, remote detection systems (e.g. for crop surveillance from airplanes), or combined with other optical spectroscopic techniques.

Further, it is noted that instrumentation issues related to various standard spectroscopic ellipsometer variants have in the last year and half been investigated in-house through Master-projects (phase modulated reflection anisotropy spectroscopy), rotating analyzer ellipsometry, rotating compensator and Fe-LC based systems. In addition, an investigation of polarisation sensitive OCT, based on liquid crystals have been performed.

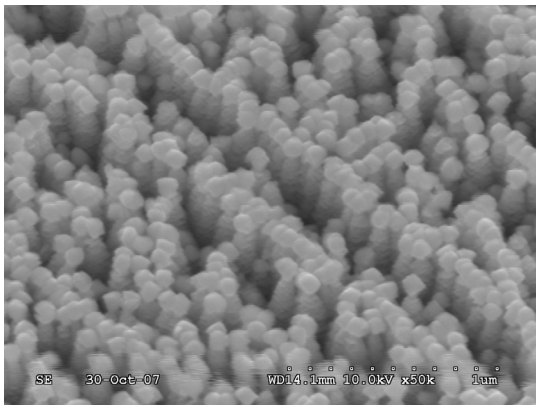


Figure 2. Busy day in Nano-land! Metal covered GaSb cones on their way to work? Wonder what their optical properties or field emission properties are like…? Sample produced by S. Leroy, CNRS, Paris. SEM images by J. Walmsley and M. Kildemo, NTNU.

Materials characterisation and modelling of optical properties and response

The main activity is related to the characterisation of nanostructured GaSb *(Nerbø, Kildemo, Simonsen)*, and similar surfaces: In particular, nanostructured GaSb have been studied by spectroscopic ellipsometry and reflectometry (0.6-6.5 eV) (Paris), Fe-LC Mueller matrix ellipsometry (430-850 nm) (in-house), and VUV-ellipsometry *(Bessy, Berlin)*. It is found that the anisotropic effective medium theories can be used to model short GaSb cones, while the longer cones shows an increasing depolarisation that cannot be modelled through the commonly applied existing methods. New theories are investigated in order to understand these results.

In addition to optical characterisation, related complementary techniques such as AFM, SEM and HR-TEM are being used. Of particular interest this year was the measurement of the field emission properties of nanostructured surfaces as a part of the CLIC collaboration.

Laser physics

(I. Sorokina)

The laser physics group works in the field of optics, photonics, atomic and molecular physics, sensing and biomedical applications with the following two main activities:

Advanced solid-state laser technology: development of the solid-state and fiber laser sources and systems.

Applications: development of these sources for high-resolution spectroscopy, trace gas and remote-sensing, LIDAR, imaging, breath analysis, etc.

Advanced solid-state laser technology

Ultrafast laser development has been a core expertise of the group, when it split from the Photonics Institute of the Vienna University of Technology in 2007, and has included the development of novel ultrabroadband solid-state laser systems, generating ultimately short femtosecond pulses in the new wavelength regions. The work has a strong emphasis on exploiting novel laser media and developing versatile ultrafast laser systems with broad spectral coverage for scientific and technological applications. In the last few years the most notable novel lasers, which have been developed and represented the highlight of the research, included the following:

The first femtosecond Cr^{3+}:LiSGaF and Cr^{3+}:LiSAF laser, operating around 860 nm and delivering down to 14 fs pulses (corresponding to five optical cycles);

Directly diode-pumped KLM and SESAM controlled femtosecond Cr^{4+}:YAG laser, operating around the very interesting communications wavelength of 1.5 µm and delivering ultrashort pulses of only 25 fs (also five optical cycles at this wavelength);

The first femtosecond Cr^{2+}:ZnSe laser, operating around 2.5 µm, and producing 80 fs pulses (corresponding to ten optical cycles at this wavelength).

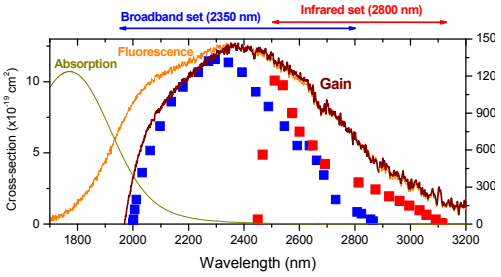


Figure 3. The absorption, fluorescence and gain curves of Cr^{2+}:ZnSe laser. The bandwidth of tuning (over 1100 nm) required two mirror sets (blue and red points).

The main advantage of all these lasers over commercially available and rather costly Ti:sapphire lasers, emitting approximately in the same wavelength range as Cr^{3+}:LiSGaF/ Cr^{3+}:LiSAF lasers, is the possibility of using the diode lasers as rather cheap and compact pump sources. These diode-pumped solid-state lasers can be compact, efficient and portable, enabling their broad practical use.

The Cr^{2+}:ZnSe laser, belonging to the family of Cr^{2+}: II-VI lasers are of particular importance for applications. These mid-IR sources, operating in the very interesting "molecular fingerprint" region between ~1.6 and 3.5 µm offer the broadest bandwidth from all solid-state vibronic lasers (Figure 3). The Cr^{2+}:ZnSe laser has not only the widest and the highest gain, but also operates at

room-temperature and produces the shortest pulses of just a few optical cycles around 2.5 μm directly from the resonator (Figure 4). Ten years after their invention, Cr^{2+}-doped lasers have come of age and emerge in applications, demanding high power and extreme bandwidth.

Applications

For femtochemistry, molecular time-resolved measurements, molecular spectroscopy, trace gas analysis, biomedical applications, etc. one should directly reach molecular frequencies. Near-IR and mid-IR tunable and femtosecond sources are required, which would possess sufficient bandwidth and have a good spatial coherence (preferably TEM_{00} mode), are low-cost, compact, directly diode-pumpable.

Recent availability of the room-temperature diode-pumped broadband tunable solid-state lasers as simple and compact alternatives to semiconductor lasers and nonlinear optical frequency conversion devices in this wavelength region is a significant step forward in remote sensing and trace gas detection, as well as in other medical applications. Indeed, the biological tissue has maximum absorption around ~2.9 μm mostly due to the water content. Therefore, such medical applications as ophthalmology, tissue cutting and welding, neurosurgery, dermatology and bio-imaging would benefit from broadband and rapidly tunable coherent sources in this wavelength region.

The ultrabroad gain bandwidth of some laser crystals allows generation of the ultimately short pulses of only a few optical cycles. Such pulses, especially in the mid-infrared range are unique diagnostic tools for numerous transient processes on the femtosecond scale. These lasers are also attractive for such applications as MIR free-space communications, optical frequency standards as well as optical coherence tomography (OCT) and fast FTIR high-resolution spectroscopy.

The ultrabroad spectral coverage of ultrashort pulsed lasers calls in particular for their spectroscopic and trace gas applications. Just as an example, very recently we realized application of frequency comb at 1.5 μm to trace-gas measurements of simultaneously several gases (Figure 5). The high brightness and good special coherence of the applied sources allowed improvement (in comparison to conventional lamps) in acquisition time during FTIR-based spectral measurement by two orders of magnitude, making these sources for the first time practical tools for sensing applications.

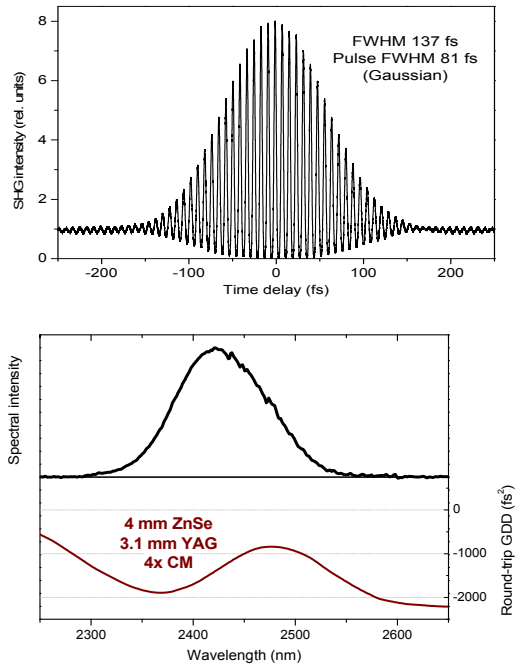


Figure 4. The spectrum and the autocorrelation trace of the shortest pulses from Cr^{2+}:ZnSe laser (80 fs).

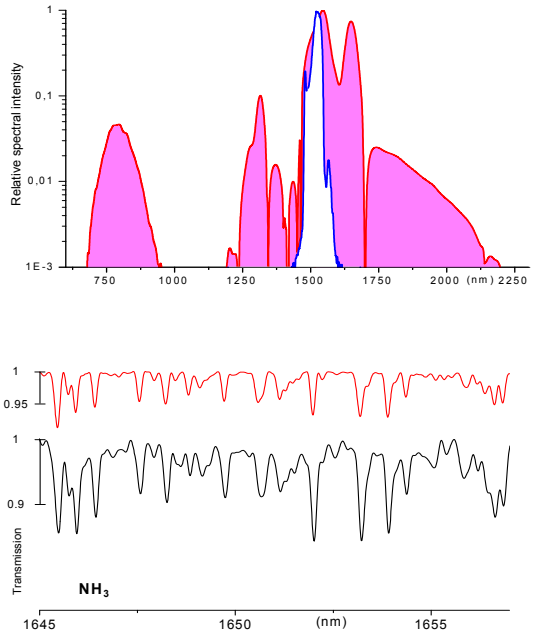


Figure 5. Spectra of the frequency comb (red) and of the pulse (white), produced in photonic crystal fiber from the femtosecond Cr:YAG laser. Below is the example of the ammonia spectrum, measured with this laser system (red-lamp, black-laser). Due to the higher brightness, the acquisition of the spectrum with the laser was 200 times faster than with the traditional lamp.

DIVISION OF BIOPHYSICS AND MEDICAL TECHNOLOGY

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Overview

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

A brief overview is given below, and one project is presented in more detail.

Survey of research activities

Medical technology

Transport of macromolecules in tumour tissue
(C. de Lange Davies, T. Lindmo, I. Tufto, A. Erikson, N. Reitan)
High interstitial fluid pressure and the extracellular matrix are potent barriers to the delivery of therapeutic macromolecules. Diffusion thus becomes the main transport mechanism. The therapeutic molecules have to diffuse through the extracellular matrix which consists of a structural network of collagen embedded in a gel of glycosaminoglycans. Diffusion of various macromolecules has been studied by fluorescence correlation microscopy (FCS) and fluorescence recovery after photobleaching (FRAP).

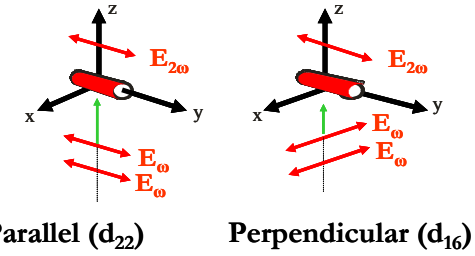

Figure 1. Collagen fibre in horizontal plane and generated second harmonic ($E_{2\omega}$) polarized parallel (d_{22}) and perpendicular (d_{16}) to excitation.

In 2007 we have focused on the collagen network and studied this by second harmonic generation (SHG). SHG is a nonlinear coherent process where two incident photons of frequency ω are converted into a single photon of twice the frequency 2ω. Collagen and other non-centrosymmetric molecules are able to generate SHG signal, and may be imaged without any exogenous labelling. Collagen fibres have been quantified by different parameters and are a promising diagnostic marker. SHG signal generation has been analyzed and modelled in a collaborative effort with the Beckman Laser Institute at University of California, Irvine. As an example we present results showing that for non-polarized detection of SHG, the perpendicular intensity contribution due to d_{16} leads to a higher resultant intensity for fibres at an angle with the horizontal plane, than due to the parallel intensity contribution alone (see Figures 1 and 2).

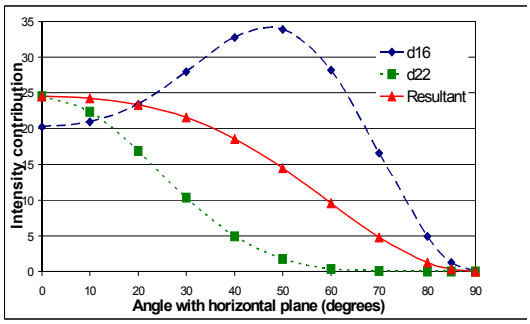

Figure 2. Resultant unpolarised SHG yield (triangles) for collagen fibre at an angle above the horizontal plan, due to weighted d_{22} and d_{16} signal contributions

DNA-vectors based on DNA-chitosan complexes are promising non-viral DNA vectors. In 2007 we have been characterizing such DNA-vectors and studied the intracellular localisation and uptake of such complexes in tumours growing in mice.

Biopolymers and bionanotechnology

Biopolymers mesoscale structural organization and interactions
(B. T. Stokke, D Klein, G. Maurstad, M. Sletmoen, S. Tierney)
The internal and collective organisation of biological polymers is crucial for life, as well as for numerous technological exploitations. Our research on mesoscale structure formation and interactions within biopolymers includes topics such as polyelectrolyte complexes, biopolymer multilayers and gels, (1,3)-β-D-glucans and their interactions with polynucleotides, physics of enzymatic mode of action, responsive gels as biospecific signal transducers and nanoscale studies of toll-like receptors. In addition to classical ensemble averaging techniques, application of single-molecule techniques is a distinctive facet necessary to tackle core issues within these topics.

Electrostatic interactions are important driving forces for numerous biological processes, e.g. organisation of DNA to packed chromosones, or interactions between enzymes and charged ligands. Our research is two-fold and includes investigating the use of chitosan (and modified chitosans) for compaction of DNA for gene delivery, and in general investigating the influence of macromolecular properties and preparation conditions on the structure of condensed semiflexible biopolymers. We have in 2007 developed methods for extraction of quantitative parameters characterising surfaces of biopolymer multilayers.

The research on (1,3)-β-D-glucans aims at an understanding of stability, structure and biological activity of (1,3)-β-D-glucans exposed to different pre-treatments. We are at present investigating complexes formed between (1,3)-β-D-glucans and polynucleotides. This is the first example of a specific polysaccharide-polynucleotide interaction.

Determination of swelling response of polymeric gels is achieved at a resolution of a few nanometers employing a Fabry-Perot interferometric technique where the gel makes up the Fabry-Perot cavity. The 2 nm resolution of changes in the optical length of the gel cavity has been utilized in designing a glucose sensitive sensor, and testing of this with respect to selectivity between various carbohydrates and various amounts of a comonomer incorporated in addition to the sensing monomer.

Bionanotechnology
(P. Sikorski, F. Mumm, M. Olderøy)
Our research is focused on characterization and application of nanostructured materials from nature, as well as on using fabrication strategies inspired by nature to make new nanostructured materials. In the past year we have continued working on applications of chitin-protein structures from the marine worm Aphroditha Aculeate as templates for fabrication of nanowires with a diameter of around 200 nm and length up to few mm. We have investigated the structure of the template using SEM, TEM, and AFM in combination with microtomy or freeze-cutting, and characterized its chemical composition and stability. Procedures for embedding of the nanochannel assemblies in polydimethylsiloxane (PDMS) were developed. Nanowire fabrication strategies based on electrochemistry (Cu, Ag) and atomic layer deposition were investigated with some encouraging results.

In 2007, we have also started work on a new project financed by NFR's Nanomat program. This project focuses on mineralization of polysaccharide gels and we aim to be able to control material/-mechanical properties of the gels by nanometer scale modifications using an approach inspired by biomineralization in nature.

Biosystems

Plant growth in weightlessness
(A. Johnson, B. Solheim)
See detailed research example presented below.

Biological effects of electromagnetic fields
(A, Johnsson, G. Oftedal, A. Straume)
Studies have concentrated on exposure to weak electromagnetic fields in the radio frequency and the low frequency regions. Possible health effects of 50 Hz fields have been the starting point for a mapping of magnetic fields in town areas as well as low magnetic frequency fields around mobile phones. Radio frequency exposure (mobile phone frequencies) of mobile phone users reporting headaches as a symptom have been carried out and reported. This double-blind experiment was a collaboration with the Department of Neurology, St.Olav's University Hospital. In June, PhD. Aksel Straume defended his doctoral thesis covering the magnetic field investigations.

Photoinduced reactions in cells
(A. Johnsson, T.B. Melø, B. Kuitert)
Photo induced reactions are studied in AY-27 cells – a bladder cancer cell line. Light induced reactions leading to cell destruction are of interest, and sensitizers added to the cells increase the light effects. Free radicals are induced in the reactions and are investigated by EPR-technique.

Photobiophysics

(R. Naqvi, T.B. Melø)

During the preceding year our main focus was on photoprotection in the reaction centre (RC) of photosystem II (PSII) of purple bacteria and higher plants and in apple fruit.

A feature common to the reaction center (RC) of purple bacteria and that of photosystem II of plants is the mechanism for the formation of $\mathbf{P}^{\dagger}$, the triplet state of the primary electron donor **P**. Once formed, $\mathbf{P}^{\dagger}$ may suffer unimolecular deactivation, or it may undergo bimolecular quenching, particularly by an adjacent carotenoid (Car), or a ground-state oxygen molecule $^3O_2(^3\Sigma_g^-)$, hereafter abbreviated as **X**. At this stage, the dissimilarities between the two RC's become evident. For our purpose, it is sufficient to focus on a single facet, namely the formation of singlet oxygen $^1O_2$ ($^1\Delta_g$), hereafter abbreviated as $^1\mathbf{X}^*$: upon illumination under aerobic conditions, RC's of photosystem II do, but those of wild purple bacteria do not, generate $^1\mathbf{X}^*$. One may conclude that, in the RC of photosystem II, quenching by Car cannot compete with quenching by **X**, and that the latter quenching is the result of an energy transfer process that may be depicted as follows: $\mathbf{P}^{\dagger} + \mathbf{X} \rightarrow \mathbf{P} + \mathbf{X}^*$. So far as quenching by **X** is concerned, it makes more sense to compare the RC of photosystem II with the RC of carotenoidless mutants of purple bacteria; under appropriate conditions, formation of X* was indeed observed in the mutant, and the kinetics of this process were investigated.

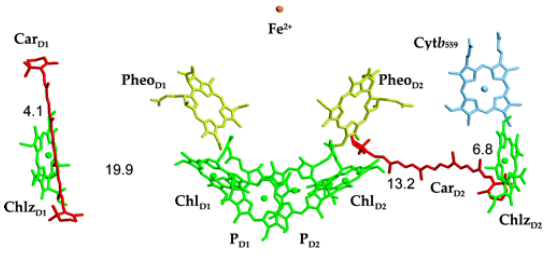

Figure 3. Pigment arrangement in the photosystem II reaction center. Relative locations of pigments, non-heme iron, and cytochrome b_{559} in the most active and stable form of the reaction center of photosystem II are based on the 3.0 Å resolution structure of cyanobacterial photosystem II. Relevant π-π system distances for this study ($Chlz_{D1}$-to-Car_{D1}-to-Chl_{D1} and $Chlz_{D2}$-to-Car_{D2}-to-Chl_{D2}) are given in angstrom

The pigment organization in the most stable form of the RC of PSII is shown in Figure 3 (above); it binds six chlorophyll (Chl) molecules (and is frequently called RC-6), two pheophytin (Pheo) molecules, and two β-carotene (Car) molecules. A pigment-deficient version, called RC-5, lacking one Chlz and one Car, was examined by pump-probe spectroscopy. The results showed that the two missing pigments were $Chlz_{D2}$ and Car_{D2}; the absence of these pigments led to the unprecedented observation of secondary electron transport in D1.

Whole apple fruit widely differing in pigment content and composition was examined in the visible and near UV regions, using its chlorophyll fluorescence excitation and diffuse reflection spectra. Spectral bands sensitive to the pigment concentration were identified, and recipes for non-destructive assessment of anthocyanins, carotenoids, and flavonols *via* chlorophyll fluorescence measurements were developed. The adaptation of apple fruit to high light stress involves accumulation of these protective pigments, which absorb solar radiation in broad spectral ranges extending from UV to the green and, in anthocyanin-containing cultivars, to the red regions of the spectrum. In ripening apples the protective effect in the blue region could be attributed to extrathylakoid carotenoids. A simple model, allowing the simulation of chlorophyll fluorescence excitation spectra in the visible range and a quantitative evaluation of competitive absorption by anthocyanins, carotenoids and flavonols, was constructed. It was concluded that anthocyanins, carotenoids and flavanols play, in fruit with low-to-moderate pigment content, the role of internal traps (insofar as they compete with chlorophylls for the absorption of incident light in specific spectral bands), affecting thereby the shape of the chlorophyll fluorescence excitation spectrum.

Neural mechanisms in vision

(A. Valberg, T. Seim)

Building upon experiments from the lateral geniculate nucleus (LGN) of the macaque monkey, we have developed a model of neural processing of visual information that starts in the cone receptors and continues in the opponent cells of the retina and the LGN.

The linear excitation of each of the three types of cone receptors to direct stimulation is modified in accordance with a hyperbolic response function before providing inputs to retinal ganglion cells. Using weighted differences of these cone inputs, we have simulated the responses of the common six types of opponent retinal ganglion and geniculate cells to lights varying along the chromatic and luminance dimensions. Using this simulation and extrapolating our data we have suggested a way in which the brain might combine inputs from the geniculate cells as vectors to obtain correlates of colour and lightness and brightness perception in areas V1 and V2.

This project has been supported by the Norwegian Node of International Neuroinformatics Coordinating Facility (INCF), and the results have been presented at two international conferences. A paper has been accepted for publication.

Neural processes and visual perception
(A. Valberg)
This theoretical project was initiated by Tambartun National Rescource Centre for the Visually Impaired. It focused upon possible correlations between the early neuronal activities in the visual pathways (of magnocellular, parvocellular, koniocellular cells) and perception. Although such correlates clearly exist, it is at a retinal level difficult to decide whether neural activity is more related to the physical stimulation (e.g. wavelength) than to the perceived magnitude (like colour).

Example of research carried out in 2007

Plant growth in weightlessness
(A. Johnsson, B. Solheim)

Figure 4. Processed double exposure (45 min interval) of Arabidopsis movements at 1g.

In an experiment onboard the International Space Station, ISS, the biophysics group carried out an experiment to study the influence of weightlessness on plant growth processes.

The experiment was a joint effort with the Plant Biocentre, also at our University, and had two goals: studies of the possibilities to achieve seed to seed production in microgravity *and* to study cellular, coordinated growth phenomena that manifest themselves as rotational movements of plants' stems and stalks.

Ever since Darwin's days the influence of gravity on such movements as those depicted has been debated. The movements may be due to self-sustained coordinated cellular elongations that move around the plant stem. Much like onlookers in a football stadium 'do the wave' one can imagine growth promoting hormones travelling around the stem giving rise to the synchronized and detectable macroscopic bending of the stem (Figure 4).

But the role of gravity in growth processes is essential to investigate. The European Space Agency has developed a “green-house" hardware onboard ISS for such studies. The groups at NTNU have taken part in the development of this equipment. For example, extensive tests and pre-experiments have been carried out to construct plant cultivation chambers, automatic watering, automatic air flow control, light control etc.

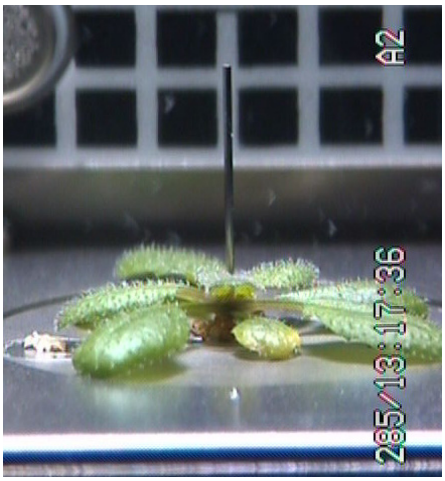

Figure 5. Picture of growing plant in weightlessness on the International Space Station (ISS).

The first long term, automatic experiment to be performed in ISS was carried out by the Trondheim groups and started in August 2007 and was stopped on Nov 2nd. The downloading of data and images took place through a complex network, connecting ISS, NASA in Houston, ESA and the established Norwegian User Support and Operation Centre at our University (N-USOC).

Image sequences in the experiment were downloaded throughout the experiment at intervals of about 5 min. Tests of the hardware as well as plant experiments were carried out. Our biophysicists collected about 30 000 images (e.g. Figure 5) of growing plants – showing e.g. rotational movements of stems and side shoots. The interpretation of the movements in the classic specimen used, *Arabidopsis thaliana*, have not been published yet, but support the hypothesis that the rotational movements in this plant are minute in weightlessness but much larger on earth and on slow centrifuges.

DIVISION OF COMPLEX MATERIAL

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Overview

The research is focused on the *physics of soft and complex material*s including *biological physics.* The phenomena studied include: The structure and dynamics of nanostructured surface alloys; Structural phase transitions in ferroic compounds, clay containing systems and biopolymers; Spontaneous and guided selfassembly of nanoparticles of various kinds; Diffusion properties in nanoporous media; 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- and small - 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 nanocalorimetry; Thermo-gravimetry; Studies of dynamic electro-optic properties of soft materials; Circular dichroism; Isolation and purification of nanoparticles including biopolymers. Some members of the section are also regular users of the synchrotron facilities in Grenoble, France; Sao Paulo, Brazil; and Pohang, South Korea.

The *computer simulation methods* include Brownian dynamics, Monte Carlo, discrete element methods, solution of boundary value problems.

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

Survey of research activities

Experimental and theoretical studies of the dynamics and structure of nanoparticles and polymers
(*A. Elgsæter and A. Mikkelsen*)
Our activity is within the physics of polymer and nanoparticle systems with a primary goal to gain a deeper understanding of the interplay between functions and structural dynamics. The research consists of three closely integrated parts: I) Formal theoretical basis for the nanoscale dynamics using realistic molecular models. II) Numerical algorithms to carry out numerical Brownian dynamics simulations. III) Experimental studies of molecular dynamics using methods such as static and dynamic light scattering, nanocalorimetry, electron microscopy, circular dichroism and electrically induced transient birefringence. Research in 2007 has been focused on electron microscopy and electron diffraction of carbon nanocones. In August 2007 a circular dichroism instrument from Olis, USA was installed, financed as a co-project between Department of Chemistry, Department of Biotechnology and Department of Physics. This state-of-the-art instrument has double beam technology, facilities for rapid scanning of wavelengths and includes a cryogenic cell holder making it possible to measure samples down to liquid nitrogen temperature. Fluorescence spectra can also be recorded.

Experimental investigations of soft and complex materials: From nano to macro.
(*J.O. Fossum*)
The research group has during several years focused on basic understanding of problems within soft and complex materials, in particular physical phenomena in soft matter using synthetic nanolayered silicates (clays) as a physical complex model system. Main physical phenomena studied in these systems include flow and diffusion processes, intercalalation processes,

spontaneous selfassembly into liquid crystalline phases in systems of nanoplatelets, and guided self-assembly into electrorheological and magnetorheological smart material properties. During the past year the activity has moved into including similar phenomena in other types of nanoparticle systems, such as gold, silver, surface modified clays and ZnO. 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, PAL in South Korea and other sources); neutron scattering (at IFE, Kjeller); and wide- and small-angle X-ray scattering at NTNU.

Brittle fracture, two-phase flow in porous media, econophysics
(*A. Hansen*)
The main research interests for 2007 have been concentrated on brittle fracture and other breakdown phenomena, on two-phase flow in porous media, and on econophysics. The activity on brittle fracture continues to be focused on the scaling properties of fracture surfaces, both analyzing experimental data and in connection with model systems such as the fuse model. We have also used the fiber bundle model as a "laboratory" for investigating further precursors that signal imminent failure. In connection with immiscible two-phase flow in porous media, we have found a new instability that occurs during crossflow, i.e. when two fluids flow in parallel in the porous medium. Earlier work on this situation has indicated that the interface undergoes the Kelvin-Helmholtz instability. This is not correct. The instability proceeds through the generation of a foam layer at the interface between the two fluids. Bubbles of the less-wetting fluid then form and diffuse into the wetting fluid, causing the foam layer to move at a constant speed and thickness towards the less-wetting fluid. In connection with studying steady-state two-phase flow in porous media, we have started a close collaboration with the company Numerical Rocks AS, Trondheim. The econophysics activity has been concentrated on understanding the mechanisms behind speculation bubbles. We have also studied the redistribution of wealth based on Norwegian data.

Crystallographic studies of materials structure and properties.
(F. Mo)
Ferroic materials: Work has been devoted to studies of epitaxial thin films, in particular to improving existing experimental procedures and optimizing the instrumentation. Ferroelectric $PbTiO_3$-films of thickness ~ 5 – 20 nm deposited on $SrTiO_3$ have been studied, also under electric fields up to 2.5 kV/cm, by the use of a specially designed sample cell. Targets for the studies are atomic/molecular structure, domain structure and dynamics, and their dependence on film thickness and electric field.

X-ray induced damage in molecules: Combined time-resolved X-ray diffraction and Raman-studies of the nature and evolution of X-ray induced radiation damage in a small organic S-containing model compound. The results are presumably relevant also for bio macromolecules for which radiation damage is a serious problem.

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

Cavity quantum electrodynamics and anomalous diffusion in granular/traffic flows
(*Bo-Sture Skagerstam*)
We have focused our attention on the large-time statistical properties of granular flows (work done in collaboration with J.O. Fossum and A. Hansen and project/master students). In this study use has been made of the so-called Hurst exponent to classify the large-time properties of granular/-traffic flows and properties of stochastic differential equations. Some features of the large-time behavior can be interpreted as anomalous diffusion. We have shown that such an anomalous diffusion can be described in terms of a conventional memory function in contrast to the sometimes used method of fractional derivatives.

In the field of cavity quantum electrodynamics we have studied various collective effects of atoms interacting with a micro-cavity radiation field. We have also studied the Purcell effect for atoms close to superconducting bodies. We have suggested that the low-frequency dielectric properties of superconducting bodies, which to a

large extent is poorly understood, can be investigated by means of spontaneous emission of atoms. The research project on the human eye as a quantum-mechanical detector of photons has continued in collaboration with project/master students. Various features of a predictive model for the response of the human eye on low intensity (quantum) light have been investigated.

Example of research carried out in 2007

X-ray induced radiation damage in taurine studied by combined time-resolved X-ray diffraction and Raman spectroscopy
(Jon Are Beukes, Frode Mo, Wouter van Beek)

Many compounds of organic or biological origin are sensitive to X-rays; radiation damage (RD) frequently occurs and may bring about a dramatic shortening of the lifetime of a crystal under exposure. The occurrence of RD is very well recognized in macromolecular crystallography. Various strategies for minimizing its impact on the structure can be implemented, however, the understanding of its nature is still incomplete. Very often the onset and evolution of RD is manifested by an irreversible increase in *d* spacings with radiation dose, and it has even been proposed to use this effect as a metric for RD development.

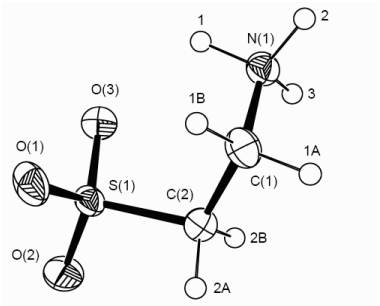

Figure 1. Molecular structure of taurine.

We have used crystals of the amino acid taurine for the investigation of radiation-induced effects with the aim to understand the underlying mechanisms of interaction. Taurine is a very simple molecule containing sulfur (Figure 1). In the crystal it adopts a zwitterionic configuration (NH_3^+─CH_2─CH_2─SO_3^-), the dipole moment is 15.5 D. Taurine should be a well suited model compound for many radiation-sensitive small organic molecules, and as well for more complex S-containing molecules including proteins. In this study we have combined synchrotron X-ray diffraction and vibrational spectroscopy in time-resolved *in-situ* experiments to observe possible radiation-induced structural changes, presumably involving changes in charge distribution and polarizability, taking advantage of the paired view that can be gained from two independent experimental techniques.

High-resolution powder diffraction and Raman spectroscopy were combined at 296 K in two series of experiments. The most extensive one lasted for 120 h, data sets being collected for time slots of ~ 2 h. Single crystal diffraction data were collected both at 120 K and 296 K, total duration/ time-slot for individual data sets in the two runs being 40/3.25 h and 66/3.75 h, respectively.

The most striking changes with accumulated dose were an irreversible increase in the unit-cell *c* axis (Figure 2), and also in the main components U_{ii} of the anisotropic atomic displacement parameters (ADPs), in particular in U_{33}, the component along *c**, for the oxygen atoms (Figure 3). All these shifts were highly significant. Small shifts of some Raman lines and a general broadening were seen, but no new lines occurred.

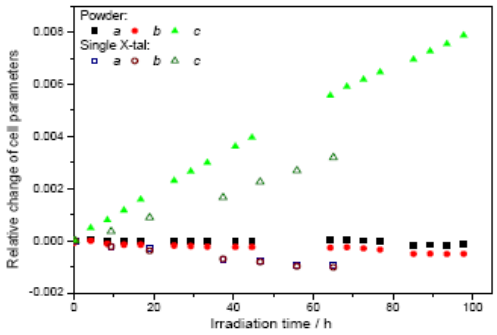

Figure 2. Evolution with irradiation time of the unit cell parameters at 296 K.

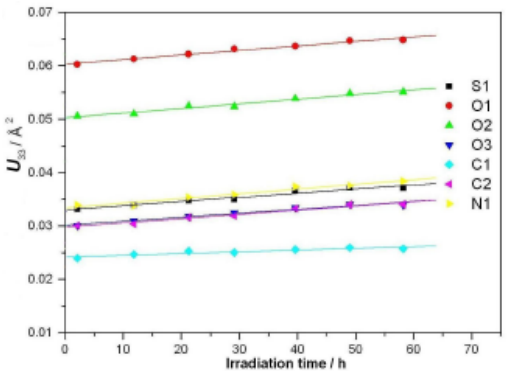

Figure 3. Evolution with irradiation time of the ADPs U_{33} at 296 K.

There were no systematic shifts either in bond lengths/bond angles or in the H-bond parameters with increasing exposure for either series of experiments, indicating a negligible impact of the radiation on the structure. However, calculations of the residual electron density within the molecule reveal a gradual depletion of positive charge near the S site and an enhancement of negative charge in the C─S and in the three S─O bonds, pointing to an increased egative charge in the SO_3 group (Fig. 4).

It has been reported that γ-irradiation of taurine leads to the formation of $\bullet SO_2^-$ radicals. From the radiation of the experiment at 296 K, having a flux estimated at 1×10^{10} photons s^{-1} mm^{-2}, about 1.8×10^{-4} photons will be absorbed per molecule of our single crystal. The energy is sufficient to initiate radical formation, predominantly involving the SO_3 group. In secondary reactions molecular species that are distinct from taurine can be formed in minute quantities, thereby introducing local departure from crystalline order, *i.e.* enhanced static disorder and a build-up of local strain. Our study provides evidence for ascribing the linear increase in ADPs to the accumulation of static disorder and not to a thermal effect. The increase of the *c* axis reflects the fact that the crystal structure is tightly interlocked by H-bonds in the *ab*-plane, expansion is energetically favoured in the more loosely packed *c* direction. This observation is corroborated by the fact that thermal expansion is almost exclusively confined to the *c* axis, the other two main axes remaining nearly constant, *b* even showing a slight contraction. The red or blue shifts of some of the Raman lines are in agreement with this anisotropy in intermolecular cohesion, and intensity shifts in several lines with exposure attest to changes in polarizability.

The experimental work was carried out on the Swiss-Norwegian Beamlines at ESRF (J.A. Beukes, F. Mo, W. van Beek (2007) *Phys. Chem. Chem. Phys.* **9**, 4709-4720).

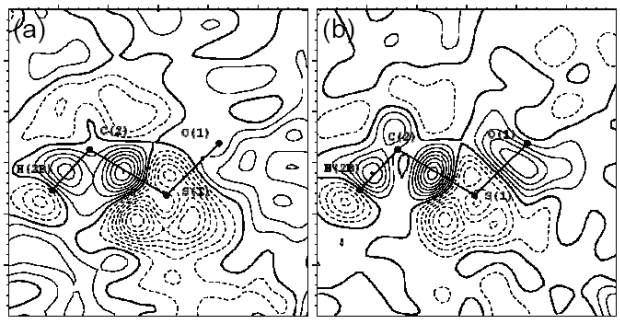

Figure 4. Residual electron density in one of the C─S─O planes; (a) calculated from the first data set after 0.5 – 4.3 h exposure, (b) calculated from the last data set after 56.6 – 60.3 h exposure. Equidistance: 0.05 e/Å^{-3}. Negative contours (positive charge) are hatched, heavy line is the zero contour.

DIVISION OF CONDENSED MATTER PHYSICS

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Overview

The research activities include topics both in experimental and theoretical condensed matter physics. The members of the division work with a variety of experimental techniques, ranging from scanning tunneling microscopy, electron microscopy, X-ray diffraction and optical spectroscopy to synchrotron radiation, for studying physical properties of materials and material structures. A large fraction of the research is focused on nanoscale structure studies and the connection to macroscopic physical properties. The group is therefore heavily involved in the establishment of the new Nanolab at NTNU A brief survey of the research is given. One research project is described in more detail.

Survey of research activities

X-ray scattering
(D.W. Breiby, R.H. Mathiesen, E. J. Samuelsen)
Breiby and Mathiesen were both hired in 2007 to work with X-ray characterization methods applied to functional and structural materials. The laboratory is currently being upgraded and consists mainly of a rotating anode source with two associated diffractometers; a high flux setup for weakly scattering organic samples and a 4-circle diffractometer which in the near future will be used mainly for thin film studies. In addition to the laboratory activities, Breiby has continued a wide range of organic electronics related projects with leading European research institutions, mainly the University of Copenhagen. Amongst the topics investigated is development of software for simulating grazing-incidence wide-angle X-ray diffraction; femtosecond time-resolved structural studies of small organic crystallites, *perylene*, nucleated on templated surfaces; diffraction studies of oriented cadmium chalcogenide nanoparticles; and investigations of *crystalline-crystalline* block-co-polymer systems where one of the blocks is the semi-conducting conjugated polymer *poly(3-hexylthiophene)* and the other block is a commodity polymer like polyethylene for improved mechanical properties. Initiatives have been taken to relate the expertise within X-ray characterization to local research, exemplified by starting a project related to ferroelectric thin-films in collaboration with the Department of Electronics and Telecommunications.

Mathiesen, who started in his new position Sept. 1st, has mainly been occupied with the continuation of ongoing project activities concerned with different fundamental topics of metals and alloy solidification. Two new projects were started in spring 2007. EquiSol is a 3-year project financed by NFR FRINAT, and is a collaboration between Department of Physics and Department of Materials Technology, NTNU, and University of Iowa, USA, focused on improving current micro- and mesoscale models for equiaxed dendritic growth. XRMON is a 3-year project funded by the European Space Agency and different national agencies, with Mathiesen as project coordinator. XRMON engages 8 European partners, and is focused on use of in situ X-ray imaging techniques to investigate non-equilibrium microstructure formation and various important process phenomena during solidification. XRMON connects to 5 other international materials- and process focused research projects, where modelling activities are central. Another European Space Agency-funded project, Monophas, with 9 European partners was concluded at the end of 2007 with the production of a new Al-Bi-Zn-based alloy for slide bearing applications, showing a 30% improvement in tribological properties relative to existing commercial alternatives.

Transmission electron microscopy (TEM)
(R. Holmestad, A.T.J. van Helvoort, J.Walmsley)
The transmission electron microscopy (TEM) research group is active in several projects including nanoscale structure studies and the connection to macroscopic physical properties, within the field of materials physics. The group has 6 PhD students, and work in close collaboration with SINTEF through the TEM Gemini centre. Ton van Helvoort was hired as associate professor in the group in august 2007.

The group has for many years worked with SINTEF and Hydro Al on alloy development and nucleation of precipitates in aluminum alloys, including structure determination of metastable hardening phases by combining experiments and modeling. In 2007 two new projects were started in this field, one on high temperature stable aluminum alloys and another on initial clustering and nucleation, including atom probe experiments.

In addition the group has research activities on other materials, such as:

- Multicrystalline silicon solar cell materials and defect engineering in 'dirty' silicon
- Palladium membranes for hydrogen gas separation
- Electronic structure of thermoelectric materials
- Materials for hydrogen storage
- Functional perovskite materials - ferroelastic sintered materials, ferroelectric thin films and nanorods
- Nanoparticles and support in catalyst materials
- High temperature corrosion in steels
- Nanowhiskers of III-V semiconductors
- Aluminum surface properties related to corrosion

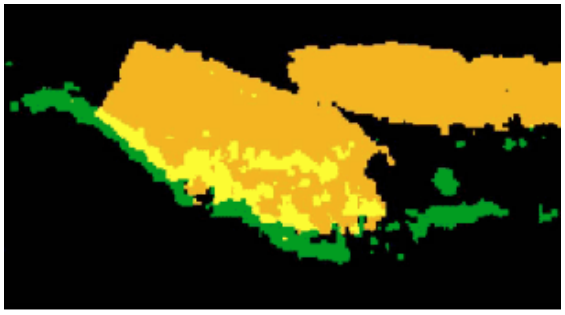

Figure 1. Lead segregation under thermal oxide in an aluminum surface which affects corrosion properties. (From Walmsley (JC) et al, Journal of the Electrochemical Society, 154, C28-C35, 2007. Collaboration with K. Nisancioglu, IMT, NTNU).

Wave propagation in layered media
(Ola Hunderi)
"Modelling of Controlled Source Electromagnetic Data" treats modelling of electromagnetic fields from controlled sources in geophysical applications. The focus is on modelling the marine CSEM (controlled source electromagnetic) method in planarly layered media. The recent introduction of SeaBed Logging (SBL) as an application of the marine CSEM method for direct hydrocarbon identification, has resulted in increased survey activity, and expanded as well as renewed the interest for investigating electromagnetic field propagation in the subsurface of the earth. Even if electromagnetic field propagation in layered media is a rather mature research subject, the current development of the CSEM and SBL methods demands reinvestigations and new theoretical insights. Optimal survey planning and solid interpretation rely on a thorough understanding of the signal propagation in the subsurface. The main motivation in the work is to contribute to increased knowledge of how electromagnetic fields travel in the earth.

In 2007 the work was focused on obtaining a better understanding of how lateral limitations of a target affect the marine EM data. As an introduction to this we study analytically scattering from conducting objects, with a focus on Mie type scattering in conductive media. We have also made kinematic ray-tracing of electromagnetic fields in conductive media.

Scanning tunnelling microscopy
(E. Wahlström, DeZheng Yang, A. Borg, T. Højberg Andersen)
The scanning tunnelling microscopy group has two major lines of research activities primarily based on the scanning tunnelling microscopy instruments in the department, namely nanomagnetics and surface science. There are two ultra high vacuum STM's operated by the group, one of which has been upgraded with sources and electron energy analyser for UPS/XPS analysis during the last year. In addition to this two scanning probe microscopes are being constructed to allow for high bandwidth (<40 GHz) studies of magnetodynamics.

Surface science
The surface science activities are primarily directed to experimental investigations of adsorption behaviour at bimetallic surfaces by scanning tunnelling microscopy (STM) and high-resolution photoelectron spectroscopy (HRPES). The HRPES studies are performed at MAX-lab, the synchrotron radiation laboratory at Lund University, Sweden. The experimental work is complemented with density functional theory calculations performed at Division of Theoretical Physics. A new line of research is studies of adsorbates on anatase surfaces through collaboration with Uppsala University:

- Adsorption at NiAl single crystal surfaces
- Adsorption at PdAg single crystal surfaces and surface properties of PdAg membranes
- Adsorbates at anatase surfaces

Experimental Nanomagnetics
The research on nanomagnetics is dedicated to understanding the physics of magnetic structures at the nanoscale. In particular STM-based transport measurements are utilised to understand how charge and spin currents within materials interplay

with the magnetisation of materials. A main line of research is performed in conjunction with the Department of Electronics and Telecommunications (Prof. T. Tybell) to study functional metal oxides. The specific activities are during the last year has been performed mainly along these lines:

- Nanostructuring and magnetic properties of $La_{1-x}Sr_xMnO_3$
- Model systems for current induced magnetisation reversal investigated through laterally resolved point contact studies.
- Transport properties of (Ga,Mn)As nanowires.

Example of research

The STM-group develops experimental methods for preparing and characterizing devices with spin dependent electronic properties. Devices made from such materials are today important as they form the basis of the information age, where giant magnetoresistivity (GMR) and tunnelling magnetoresistivity (TMR) devices are used as magnetic read-heads. In a first study we have used STM based point contact measurements to map the resistance in differently shaped GMR spin-valve elements.

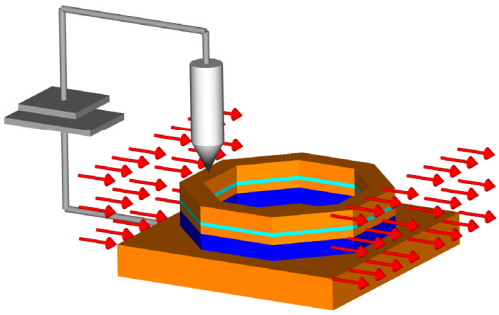

Figure 2. Measurement geometry: the STM-tip is pushed into the sample and local measurements of the magnetoresistivity are made. The sample is a GMR-sandwich of Cu/NiFe/Cu/Co/Cu, ~100nm thick, which has been etched through to produce well defined shapes.

Spin-valve elements were prepared from multilayer (Cu/NiFe/Cu/Co/Cu) films through electron beam lithography and investigated in a configuration where the current is sent perpendicular through the film through point contacts. When the two magnetic layers (Co and FeNi) have parallel magnetisation the resistance will be low, when the magnetisation is antiparallel there will be a higher resistance due to the GMR effect. Here we present some data from octagon shaped ring structures where the correlation between switching field and current sent through the structure has been investigated.

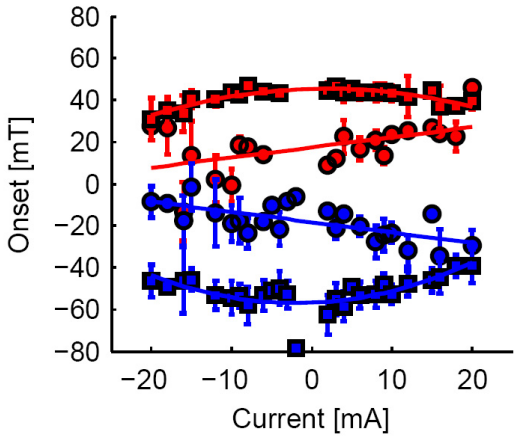

Figure 3. The sense current dependence of the field onset of field induced magnetisation reversal. The colours indicate different field sweep directions. The magnetically soft NiFe layer (rings) has an asymmetric behaviour indicative of current induced effects while the hard Co layer (squares) has a symmetric behaviour indicative of Oerstedt heating effects.

In ring elements the magnetoresistance was probed as a function of the lateral position of the contact, the applied field and the sense current. Magnetisation reversal was observed; both as induced by changing the magnetic field and the sense current. The field induced reversals are interpreted as a consecutive rotation of the onion states of the Co layer and the NiFe layer. The current induced offsets and the current induced magnetisation reversal can be interpreted as induced by a combination of the spin torque and the Oerstedt field of the injected current. For the thin magnetic Py layer (2.5 nm) the current induced torque dominates the current induced offsets in field switching (Figure 3). The offsets of the thick magnetic Co layer (20 nm) are dominated by the Oerstedt field and/or heating. The sense current induced offsets can qualitatively be explained by considering the magnetic domain structure of the octagons and the position of the point contact. Far away from the domain walls it is unlikely that the current induced spin torque will create a new domain, while close to the domain walls the current induced spin torque may induce motion of the domain wall.

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Dr. Tommy Øvergård (Research scientist)

Overview

The research is mainly carried out within the broad fields of condensed matter physics, statistical physics, quantum physic, astroparticle-physics. These contain several subfields with a large variety of topics for research. A brief overview is given. For the year 2007 we have given a more extended description of two research topics: Self-consistent Ornstein-Zernike approximation and strongly interacting matter.

Survey of research activities

The future of nano-electronics will require a combination of expertise in different fields by integrating semiconductors and normal metals with magnetic and superconducting materials. Our group explores spin and charge flow in such nanostructures. We aim to develop improved theoretical methods for describing transport phenomena, and other physical effects, and use these methods to increase our understanding of experiments. We study the properties of novel systems, pure or hybrid, containing ferromagnets, normal metals, semiconductors, and superconductors. Among our current projects are 1) current induced magnetization excitations, 2) two-dimensional “Dirac fermions" in graphene, 3) spin flow into superconductors, 4) transport in magnetic semiconductors, 5) fluctuations and dissipation in ferromagnets, 6) spin-dynamics in spinor Bose-Einstein condensates. We published 9 papers in 2007, among which one in Physical Review Letters and five in The Physical Review B. (*A. Brataas, A. K. Nguyen, D. Huertas-Hernando, M. Taillefumier, J. Foros, J. P. Morten, H. J. Skadsem, H. Haugen, and K. Hals*).

During 2007 we published 9 papers in Physical Review B and 1 paper in Physical Review Letters on topics ranging from 1) derivation of Ginzburg-Landau theories of ferromagnetic superconductors, 2) tunnelling and other transport characteristics of heterostructures involving novel types of superconductors, 3) novel tunnelling spectra and proximity effects in graphene, and 4) renormalization group theories of spinon deconfinement in strongly correlated fermion systems such as Mott-Hubbard insulators. In addition, we have two ongoing long-term research project going on 5) phase transitions in single- and multi-component Bose-Einstein condensates with and without rotation, and 6) large-scale Monte Carlo simulations of effective theories of quantum dissipation and hidden order in d-wave cuprate high-Tc superconductors. (*A. Sudbø, K. Børkje, E. K. Dahl, S. Kragset, J. Linder, M. Grønsleth, I. Bakken Sperstad, T. Bergh Nilssen*).

The Fermi golden rule is a cornerstone of quantum mechanics, although not included among its basic axioms. It gives a prescription for calculating constant transition ratios by e.g. perturbation theory, and predicts that a fraction of unstable particles will decay according to an exponential law. But it is known that exact calculations may lead to results which differ from the Fermi golden rule both for very long and very short times. The latter is often referred to as the quantum zeno effect. It would under certain conditions imply that a sample of unstable particles will have a time-varying decay rate, depending on their age since creation. This is at variance with the principle of absolute identity of elementary particles (implying that there is no way to distinguish young and old particles of the same type from each other) and seems to lead to a paradox. A model of this situation has been analysed within the second quantization formalism, which enforces the identity principle. It reveals the possibility of quantum mechanical rule for combining lifetimes. (*M. Drangfelt, K. Olaussen, I. Øverbø)*

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

Self-consistent Ornstein-Zernike approximation (SCOZA) combined with the virial theorem
J.S. Høye and A. Reiner
Earlier it has been shown that SCOZA produces very accurate results for the pair correlation

function and equation of state. This is also the case in the critical region that has been very difficult to handle beyond the mean-field approximation. Thus its ability to locate the critical point represents an estimate of the accuracy obtained. For the nearest neighbor Ising model in 3 dimensions the SCOZA estimate of the critical temperature is only about 0.2% from best estimates. For the typical model fluid with molecules or particles that are modeled as hard spheres plus an interaction of Yukawa form the corresponding result is about 0.6% from assumed best estimate based upon computes simulations. This estimate is with the Yukawa potential exp*(-z(r-1))/r for* particles with hard core diameter equal to 1 and with parameter z=1.8.

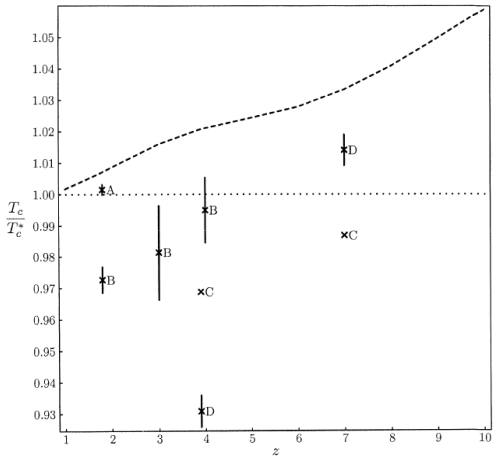

Figure 1. Critical temperatures T_c for hard core Yukawa potentials with varying inverse range z as computed by conventional SCOZA (dashed line), as well as by various simulations, relative to the predictions Tc* of our modified version of SCOZA.

In standard SCOZA an effective temperature is introduced in the MSA-form (mean spherical approximation) of the direct correlation function. We instead add an extra Yukawa term to the usual MSA-form of the direct correlation function. In this way two free parameters become available. Then with one parameter fixed consistency with the virial theorem is checked during the numerical evaluations. Instead of requiring full thermodynamic consistency we simply required consistency only at the critical point. In this way markedly improved results were obtained, and for the Yukawa fluid with z=1.8 the result for the critical temperature was within 0.2% of best estimate. This change in critical temperature was consistent with an analysis that gave an estimate of the lowering of this temperature.

Vibrational spectra of triphenyl based compounds and ions
(O.K. Eide, M. Ystenes, J.A. Støvneng, J.L. Eilertsen)
Density functional calculations were used to determine vibrational spectra of triphenyl based compounds and ions (Ph_3CCl, Ph_3CCH_3, Ph_3C^+) as well as aluminium based reaction partners (e.g. $Al_2Cl_2(CH_3)_4$). These systems are relevant to homogeneous catalysis of olefin polymerization. Calculated frequencies were compared with experiments and assignment of the observed IR bands was done by investigation of the calculated normal modes.

Metallocene-based catalysis of polymerization of ethene-*co*-1-hexene
(A.C. Möller, R. Blom, O. Swang, A. Hannisdal, E. Rytter, J. A. Støvneng, T. Piel)
A combined experimental and theoretical study suggests the existence of multiple active sites when 2-DMS- and 2-TMS-substituted bis-indenyl-zirconocenes are used to polymerize ethene, alone and together with 1-hexene. The stabilizing agostic interactions are of a different character in these bulky zirconocenes when compared with sterically more open bis-Cp systems.

Adsorption and dissociation of small molecules on chromium oxide surfaces
(*Ø. Borck, K. Nigussa, K.L. Nielsen, J.A. Støvneng*)
The chromium oxide surface has numerous applications within catalysis and corrosion resistance. The (0001) surface of Cr_2O_3 may terminate with a Cr or an O layer. In the latter case, the surface oxygen atoms may be bonded to Cr with double bonds (Cr=O) or with single bonds (Cr-O-Cr). Adsorption sites and corresponding energies have been determined for atomic H, Cl and S, and the molecules H_2, HCl and Cl_2. Dissociation of some of these molecules has been investigated with so-called “nudged elastic band" calculations, and energy barriers lie in the range 4 – 6 eV. H and S adsorb to oxygen without much reconstruction, whereas S adsorbs to a chromium atom which is pulled “outside" the oxygen surface layer.

Strongly interacting matter
(*J.O. Andersen*)
Quantum chromodynamics is generally accepted as the theory that describes the strong interactions among the quarks and gluons. Due to a remarkable property of nonabelian gauge theories called confinement, free quarks are never observed. All quarks are confined inside the hadrons. Hadrons are the bound states of a quark and an antiquark (e.g. pions and kaons), and three quarks (e.g. protons and neutrons).

If hadronic matter is heated, it is expected to undergo a phase transition to a new state of matter called the quark-gluon plasma. In this state of matter, the quarks and gluons are no longer confined but are free to move around large distances. The quark-gluon plasma is similar to an ordinary electromagnetic plasma, but is more complicated due to the nonabelian aspects of QCD. The quark-gluon plasma existed in the early

universe and so understanding its properties is essential in cosmology. In order to study the properties of the plasma, large experimental efforts at CERN and Brookhaven are made to create it in heavy-ion collisions.

Strongly interacting matter also behaves in a highly nontrivial manner if one increases the density. If the density becomes sufficiently high, there is a phase transition to quark matter, which might be in colour superconducting state if the temperature is low enough and the baryon density is high enough. This part of the phase diagram (see Figure 2) is relevant in astrophysics as compact stars are the only known candidate for containing quark matter in its interior.

We are currently carrying out research to determine the thermodynamic properties of the quark-gluon plasma and various phases of dense matter. In particular, we have been studying the possibility for Bose-Einstein condensation of pions in dense matter. This is a part of the large efforts being made to obtain a quantitative understanding of the properties of strongly interacting matter at finite temperature and density.

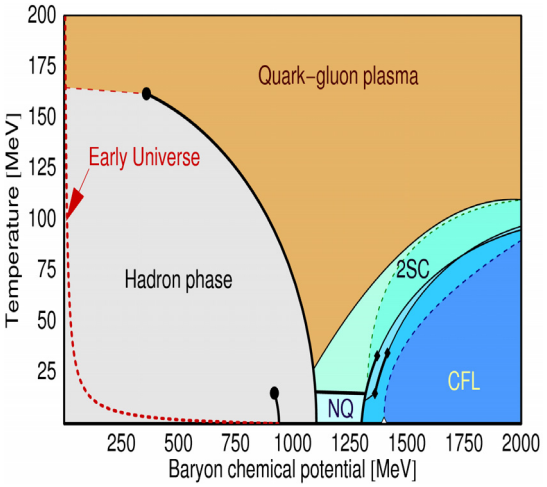

Figure 2. Phase diagram for quantum chromodynamics as a function of temperature and baryon chemical potential.

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Falnes, Johannes. Bølgjekraftforsking og -utvikling. Fagforbundets Energikonferanse; 21.11.2007 - 22.11.2007

Falnes, Johannes. Havbølgjer som vedvarande energikjelde. Møte; 15.01.2007

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Johnsson, Anders. Planter i rommet. Faglig-pedagogisk dag ved NTNU 2007; 30.11.2007

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Worren, Turid; Larsen, Jan Harald. Intervju om solceller i NRK Hordalands formiddagssending 23. mars 2007. NRK Hordaland [Radio] 23.03.2007

COOPERATING INSTITUTIONS

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* Frankfurt University, FIAS, Germany (Michael Strickland)

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* Risø National Laboratory, Technical University of Denmark, Denmark (Dr. J.W. Andreasen)
* Swiss Light Source, Paul Scherrer Institute, Switzerland (Dr. O. Bunk)
* Physik Department, Technical University of Munich, Germany (Prof. C. Papadakis)
* Max Planck Institut für Polymerforschung, Mainz, Germany (Prof. K. Müllen, Dr. W. Pisula, Dr. D. Andrienko)

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* Université Louis Pasteur, Strasbourg, France (Schmittbuhl)
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*Ecole Normale Supérieure, Cachan, France (Hild, Roux)
* Technical University of Budapest, Hungary (Kertesz)
*ETH, Zürich, Switzerland (Herrmann)

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* Umeå Universitet, Organisk kemi, Umeå (photoprocesses, organic molecules)
* Totalfőrsvarets forskningsinstitut, Linkøping (polarimetric and spectroscopic sensing; laser protecting materials and devices)
* Université Claude Bernard (Lyon1), Laboratoire des Multimatériaux et Interfaces (sol-gel/hybrid materials)

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* Johns Hopkins University (prof. Z. B. Tesanovic)
* University of Toronto (prof. John Wei)

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* Kyoto Inst. of Technology, Kyoto, Japan (K. Kajiwara) Biophysics

Sudbø, A:
*Department of Applied Physics, Nagoya University, Japan.

Australia

Davies, C.:
* Cancer Biology Laboratory, Peter Mac Callum Cancer Centre, Melbourne (Robin Anderson)

National cooperation

* Naturfagsenteret (Nasjonalt senter for naturfag i opplæringen)
* NAROM (Nasjonalt senter for romrelatert opplæring)
* Department of Chemistry, Biotechnology and Food Science, Norwegian University of Life Sciences, Ås, Norway (Prof. V.G.H. Eijsink)
* Institute for energy technology, Kjeller, Norway (senior scientists Arne Skjeltorp, Geir Helgesen, Kenneth D. Knudsen, Bjørn Hauback, Mark Pitt)
* Photocure ASA, Oslo
* Division of Biophysics and Medical Technology, Radium Hospital, Oslo (Ø. Bruland, A. Skretting)
* Statoil Research Centre, Trondheim (F. Antonsen, H. Widerøe, Erling Rytter)
* University of Oslo (J.M. Leinaas, A. Dahlback, E.G. Flekkøy, K.J. Måløy, Johan Taftø, Øystein Prytz, H. Fjellvåg, O. Nilsen)
* University of Bergen (J.Stamnes)
* Optomed (R.Ellingsen, D.R. Hjelme, B. Falch)
* FMC Biopolymers (E. Onsøyen)
* Norwegian Radiation Protection Authority (Bjørn Johnsen, Terje Christensen)
* Department of Biology, University of Oslo (D. Hessen)
* Norwegian Institutte for Air Research, University of Oslo, (A. Kylling, G. Braathen)
* Tambartun National Resource Center for the Visually Handicapped, Melhus (P. Fosse)
* Centre for Viking and Medieval Studies, University of Oslo
* Høgskolen I Finnmark (D. A. Lysne)
*Numerical Rocks AS, Trondheim (Øren)
*Fysisk institutt, Univ. Oslo (Måløy)
* Høgskolen I Sør-Trøndelag, HiST (Eli Munkeby)
* Vestfold University College (K.E. Aasmundtveit)

Local cooperation

* Skolelaboratoriet for matematikk, naturfag og teknologi, NTNU
* Program for Lærerutdanning, NTNU
* Department of Oncology, St.Olav's Hospital (T. Strickert, J. Frengen)
* Department of Circulation and Medical Imaging (O. Haraldseth, C. Brekken)
* Department of Electronics and Telecommunications, NTNU (T. Tybell, H. Wehman, J. Grepstad)
* Department of Process Technology, NTNU (P.V. Hemmingsen)
* Høgskolen i Sør-Trøndelag, HIST (G. Oftedal, S. Ramstad)
* SINTEF (C. Marioara, S. Andersen, J. Walmsley, E.S. Tanem, R. Fagerberg)
* Institutt for konstruksjonsteknikk, NTNU. (I. Brevik og J.B. Aarseth)
* Organic Chemistry, NTNU (P.H. Carlsen, E.H. Mørkved)
* Plantebiosenteret NTNU (T.-H. Iversen)
* 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. Skjåk-Bræk, S. Valla, O. Smidsrød, K.I. Draget)
* Inst. for kreftforskning, NTNU: (T. Espevik, A. Sundan)
* Institutt for Petroleumsteknologi, NTNU
* Institutt for Materialteknologi, NTNU, (K.Marthinsen, M.-A. Einarsrud og T. Grande, Ø. Grong, O. Lohne)
* SINTEF Energiforskning
* Institutt for Kjemisk prosessteknologi, NTNU (De Chen, A. Holmen, H. Venvik, M. Rønning, E.A. Blekkan)
* Department of Chemistry (A. Lykknes)
* Lysforsk, NTNU (B. Malusiak)
* Institutt for kjemi (P. O. Åstrand)

EDUCATION

SUBJECTS AND STUDENT ATTENDANCE

Some subjects were self-study courses in 2007

Subjects		*Student Attendance*
M.Sc. Technology 1st and 2nd year.		
TFY4102	Physics for Product Design Engineering, Marine Technology, Earth Sciences and Petroleum Engineering (incl. lab)	162
TFY4106	Physics for Civil and Transport Engineering, Industrial Economics and Technology Management, Product Design and Manufacturing	263
TFY4115	Physics for Electronics Engineering, Engineering Cybernetics (incl. lab)	96
TFY4120	Physics for Chemical Engineering and Biotechnology, Materials Science and Engineering (incl. lab)	93
TFY4125	Physics for Computer Science, Communication Technology	134
TFY4145	Mechanical Physics (incl. lab)	114
TFY4155	Electromagnetism (incl. lab)	78
TFY4160	Wave Physics (incl. lab)	66
TFY4165	Thermal Physics (incl. lab)	72
TFY4180	Physics for Energy and Environment (incl. lab)	106
TFY4215	Chemical Physics and Quantum Mechanics	70
M.Sc. Technology 3rd year.		
TFY4170	Physics 2 for Electronics Engineering	59
TFY4185	Measurement Techniques (incl. lab)	59
TFY4190	Instrumentation (incl. lab)	46
TFY4195	Optics (incl. lab)	38
TFY4205	Quantum Mechanics	37
TFY4230	Statistical Physics	55
TFY4240	Electromagnetic Theory	40
TFY4250	Atomic and Molecular Physics	41
TFY4260	Cell Biology and Cellular Biophysics (incl. lab)	20
M.Sc. Technology 4th year.		
TFY4200	Optics, Advanced Course (incl. lab)	17
TFY4210	Applied Quantum Mechanics	20
TFY4220	Solid State Physics (incl. lab)	46
TFY4225	Nuclear and Radiation Physics (incl. lab)	39
TFY4235	Computational Physics	37
TFY4245	Solid State Physics, Advanced Course	10
TFY4255	Materials Physics (incl. lab)	9
TFY4265	Thermal Physics	18
TFY4270	Theory of Classical Fields	21
TFY4275	Classical Transport Theory	2
TFY4280	Signal Processing (incl. lab)	27
TFY4292	Quantum Optics	17
TFY4300	Energy and Environmental Physics	33
TFY4305	Non-linear Dynamics	17
TFY4310	Molecular Biophysics (incl. lab)	7
TFY4315	Biophysics (special)	13
TFY4320	Medical Physics (incl. lab)	16
TFY485x	Experts in Team, Interdisciplinary Project	56

M.Sc. Technology 5th year.

TFY4265	Biophysical Micromethods (incl. lab)	4
TFY4500	Biophysics, Specialization Project	9
TFY4505	Biophysics, Specialization Course	7
TFY4510	Physics, Specialization Project	40
TFY4515	Physics, Specialization Course	23
TFY4550	Physics, Project	2
TFY4900	Physics, Master's Thesis	67

B.Sc.

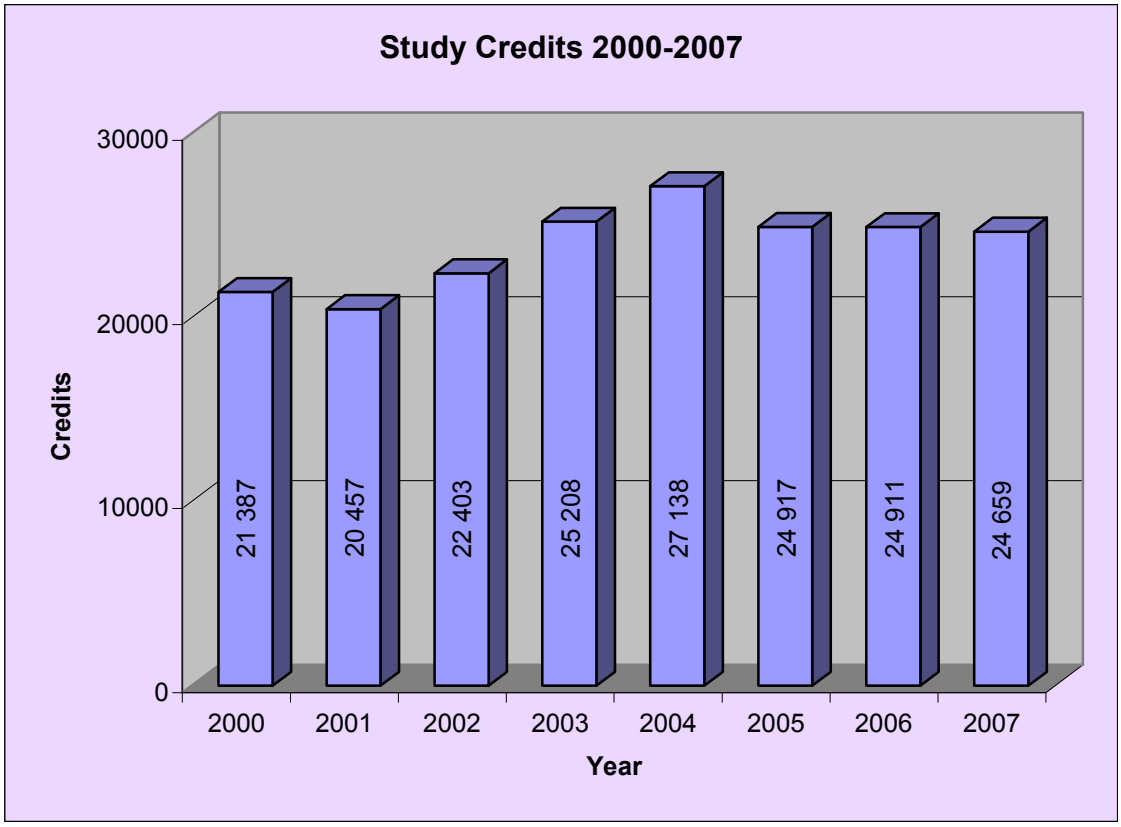
FY0001	Service Course in Physics (incl. lab)	42
FY1001	Mechanical Physics (incl. lab)	36
FY1002	Wave Physics (incl. lab)	24
FY1003	Electricity and Magnetism I	32
FY1004	Introduction to Quantum Physics	29
FY1005	Thermal Physics (incl. lab)	31
FY1013	Electricity and Magnetism II (incl. lab)	20
FY2045	Quantum Physics (incl. lab)	13
FY2302	Biophysics (incl. lab)	11
FY2450	Astrophysics	23
FY3020	Space Technology I	24

M.Sc.

RFEL3092	Research Methods in Science	8
FY2290	Energy Resources	11
FY2900	Didactics in Physics (incl. lab)	4
FY3006	Sensors and Transducers	16
FY3021	Space Technology II	15
FY3070	Light, Vision, Colour (incl. lab)	4
FY3114	Functional Materials	6
FY3201	Atmospheric Physics (incl. lab)	8
FY3402	Subatomic Physics	20
FY3403	Particle Physics	9
FY3450	Astroparticle Physics	2
FY3452	Gravitation and Cosmology	14
FY3464	Quantum Field Theory I	8
FY3900	Master Thesis in Physics	15

PhD

FY8104	Applications of Symmetry Groups in Physics	9
FY8201	Nanoparticle and Polymer Physics I	2
FY8301	Mesoscopic Physics	7
FY8306	Quantum Field Theory II	1
FY8307	Relativistic Quantum Mechanics	3
FY8401	Interactions of Ionizing Radiation with Matter	3


Study Credits 2000-2007
Credits
30000
20000
10000
0
21 387
20 457
22 403
25 208
27 138
24 917
24 911
24 659
2000
2001
2002
2003
2004
2005
2006
2007
Year

THESES - GRADUATE STUDIES

Master of Science in Applied Physics and Mathematics

Alme, Lars Ramstad
Water transport in selected nanoporous media
Supervisor: Jon Otto Fossum

Almli, Åsmund
Sample preparation and TEM characterization of ferroelectric lead titanate nanostructures
Supervisor: Randi Holmestad

Birkeland, Ole Jakob
Nonlinear Laser-induced Deformations of Fluid-Fluid Interfaces
Supervisor: Johan Skule Høye

Bjørke, Astrid Kornberg
New Method for Maintenance of Oil-Filled High Voltage XLPE Cable Terminations
Supervisor: Tore Løvaas

Bjørnsen, Hege Sjeggestad
Nanoparticle Deposition in Droplets of Clay-Water Suspensions
Supervisor: Jon Otto Fossum

Borlaug, Jan-Trygve
Measurements of High Frequency Dielectric Properties in Oil-Paper Systems
Supervisor: Tore Løvaas

Breivik, Magnus
Fourier transform photoluminescence spectroscopy of Cd(x)Hg(1-x)Te
Supervisor: Ola Hunderi

Egeland, Ellen
Compact Stars. Mass, Radius and the Significance of Dark Energy
Supervisor: Jens Oluf Andersen

Eidnes, Knut
Measurement of Moisture Content in Insulating Oils for High Voltage XLPE Cable Terminations
Supervisor: Tore Løvaas

Eikeland, Ervind
Use of the Gnome X Scanning Microscopy Project in the Construction of a Scanning Tunneling Microscope
Supervisor: Erik Wahlstrøm

Eik-Nes, Bodil
Characterisation and intracellular localization of DNA/chitosan complexes
Supervisor: Catharina Davies

Fjeld, Elin
Hard silicon blocks: Effect of grain texture and dislocations on hardness
Supervisor: Ola Hunderi

Fjellsbø, Lise Marie Bauge
An evaluation of dose level to the ipsi- and contralateral breast using different radiation techniques
Supervisor: Catharina Davies

Garberg, Torgunn
Transmission Electron Microscopy and Diffraction Study of Carbon Nanocones
Supervisor: Arnljot Elgsæter

Gjestland, Tormod
Gauge theories at finite temperature
Supervisor: Jens Oluf Andersen

Gulliksrud, Kristine
Interstitial fluid pressure compared with blood flow and extracellular volume fraction from MR imaging in human melanoma xenografts
Supervisor: Einar Rofstad

Hals, Kjetil Magne Dørheim
Geometric-phase-induced persistent currents and charge- redistribution inside a domain wall in ferromagnetic zincblende semiconductors
Supervisor: Anh Kiet Nguyen

Hatlen, Kristin
The Feynman Propagator for Klein-Gordon and Dirac Fields in 4+1 Dimensions
Supervisor: Kåre Olaussen

Hatlen, Svein Olav
Membrane World Quantum Field Theory
Supervisor: Kåre Olaussen

Hegdal, Jan Peder
Unified theories in particle physics
Supervisor: Jan Myrheim

Henriksen, Jorunn Andrea
Utilisation of ionisation chamber array for dosimetric verification of IMRTea
Supervisor: Catharina Davies

Hjelkrem, Odd Andre
The Physics of Free-Flows
Supervisor: Bo-Sture Skagerstam

Holhjem, Lars
Models for vortices and fluxlines in Bose and Fermi condensates
Supervisor: Kåre Olaussen

Holt, Liviu
TEM characterization of GaSb nanocones
Supervisor: Randi Holmestad

Holvik, Anette
Investigation on reconstruction artefacts caused by high density structures in PET-images that have been corrected for attenuation by the use of CT-images
Supervisor: Arne Skretting

Hope, Sigmund Mongstad
Burst distributions in the fibre bundle and fuse models
Supervisor: Alex Hansen

Hølto, Jorunn
Experimental Studies of a Layered, Synthetic Silicate: TGA, DSC and X-ray Scattering
Supervisor: Jon Otto Fossum

Kleven, Øystein
Multiple Quantum Well solar cell. Production and characterization
Supervisor: Turid Worren Reenaas

Kvande, Stine
Examination of Initiation Mechanisms for Water Trees Growing from the Conductor Screen in Medium Voltage XLPE Cables
Supervisor: Tore Løvaas

Ladstein, Jarle
Realization of spectroscopic Mueller Matrix Ellipsometer based on Ferroelectric Liquid Crystal Retarders
Supervisor: Morten Kildemo

Larsen, Stian
Streamer inception and propagation in transformer oil under hydrostatic pressure
Supervisor: Tore Løvaas

Lie, Øydis Østbye
Assessment of effective dose and dose to the lens of the eye to staff in interventional radiology
Supervisor: Tor Wøhni

Løvhaugen, Pål
Numerical simulations of interferometrical deformation measurements of multilayered objects
Supervisor: Ola Hunderi

Laastad, Erik Olav
Photoemission and low energy electron diffraction study of the Pd/Ru(0001) and Ce/Pd/Ru(0001) systems
Supervisor: Steinar Raaen

Martinsen, Stian
Low-Temperature Oxidation of the Ce/Fe(111) and Ce/Ni(100) Overlayer Systems
Supervisor: Steinar Raaen

Mjøs, Anders
Sensitivity of a new multi-photomultiplier optical module for neutrino detection in ANTARES/KM3NeT
Supervisor: Bo-Sture Skagerstam

Moen, Monica
Non-thermal plasma prototype development for conditioning and gas cleaning of biomass producer gas
Supervisor: Tore Løvaas

Myklebust, Oddrun Christin
Computation of viscous losses in a thruster gearbox
Supervisor: Ola Hunderi

Naqvi, Yunus Aly
Development and Calibration of a Small Angle Light Scattering Setup for Determination of Particle Sizes
Supervisor: Jon Otto Fossum

Nerbø, Ingar Stian
Optical properties of nano-structured GaSb
Supervisor: Morten Kildemo

Nielsen, Christian Andreas
An Experimental Study of Fractures in Gels
Supervisor: Jon Otto Fossum

Nordås, Ståle
Water Transport Properties in Polymeric Cable Materials; Influence of Processing
Supervisor: Tore Løvaas

Olderøy, Magnus Østgård
OIntra-Tumor and Tissue Distribution of PEG-chitosan/DNA complexeslderøy
Supervisor: Catharina Davies

Olsen, Håvard Morten
Preparation of free-standing membranes for optical waveguides in PLZT thin films on silicon substrates
Supervisor: Ola Hunderi

Opsahl, Asle
Transport processes in nanotubes, statistical properties
Supervisor: Bo-Sture Skagerstam

Pettersen, Svein Magnus
Experimental investigation of Structure functions
Supervisor: Johan Skule Høye

Rognsvåg, Guro Kahrs
Linear sigma model at finite temperature
Supervisor: Jens Oluf Andersen

Rødal, Helene
A Microscale Study of Electrorheological Behaviors of Nano-Silicate Suspensions
Supervisor: Jon Otto Fossum

Sand, Marthe Kristine
Effects of temperature on the domain wall resistance in a ferromagnetic zincblende semiconductor
Supervisor: Ahn Kiet Nguyen

Schjelderupsen, Børge Aune
A Rheological Study of Nano-Layered Silicates in an External Electric Field
Supervisor: Jon Otto Fossum

Simonsen, Trude Golimo
Blood flow in human melanoma xenografts: Comparison of dynamic contrast-enhanced magnetic resonance imaging and vital microscopy
Supervisor: Einar Rofstad

Skaftnes, Christina
Photobiophysical studies of the AY-27 cell line
Supervisor: Anders Johnsson/ Thor Bernt Melø

Slundgård, Svein Åsmund
Electric Field Induced Structures and Electrorheology of Nano-Layered Silicates
Supervisor: Jon Otto Fossum

Smith, Ivar Eskerud
Using finite element code to determine the roughness exponent in 2D brittle fracture
Supervisor: Alex Hansen

Solås, Ole Martin
Dielectric Properties of Aged Epoxy at High Temperatures and Pressures in Humid Environment
Supervisor: Tore Løvaas

Stalheim, Henning Pettersen
Construction of a low-temperature scanning tunneling microscope
Supervisor: Erik Wahlstrøm

Sund, Endre Eivind Aune
Atomatic, dynamic visualization of short-axis slices of the left ventricle
Supervisor: Catharina Davies

Svendsen, Guro Kristin
Investigation of polarization sensitive optical coherence tomography based on nematic liquid crystals
Supervisor: Morten Kildemo

Toftemo, Eli
Virkninger av lavfrekvent støy på mennesker
Supervisor: Knut Arne Strand

Torsæter, Malin
Crystal Structure Determination of the C-type Plate Precipitate in Al-Mg-Si-Cu Alloys
Supervisor: Randi Holmestad

Trebler, Marius
Alarm correlations in control systems on offshore oil and gas production platforms
Supervisor: Alex Hansen

Tverdal, Merethe Foldøy
Desorption of Hydrogen from Carbon Nanostructures
Supervisor: Steinar Raaen

Undem, Hilde
Development and testing of methods for data acquisition by instructed breath holds in deep inspiration on a PET/CT-scanner
Supervisor: Arne Skretting

Utne, Harris
Non-thermal plasmas for combustion, removal of hydrogen sulfide and other applications
Supervisor: Tore Løvaas

Windsor, Anders Thomas
Acoustic properties of motorcycle helmets
Supervisor: Ola Hunderi

Cand.scient in Physics

Dybvik, Ole-Petter
The Gauge/Gravity Correspondence
Supervisor: Bo-Sture Skagerstam

Gjendem, Amund Gjerde
Oppsett, gjennomgang og videreutvikling av et spektroradiometer
Supervisor: Jørgen Løvseth/Berit Kjeldstad

Hopstad, Yngve
Sammendrag om hvordan stjerner med 10 til 50 solmasser blir til type II supernovaer
Supervisor: Jan Myrheim

Hansen, Leif Ove
Disk Accretion and the Spin Evolution of Pulsars
Supervisor: Jan Myrheim

Master in Physics

Berland, Kristian
Finite-temperature resummation in sigma models
Supervisor: Jens Oluf Andersen

Drangfelt, Marie
The Quantum Zeno effect and identical particles
Supervisor: Kåre Olaussen

Egge, Sigbjørn Vindenes
On Quantum Key Distribution and Weakly Disturbing Eavesdropping
Supervisor: Jan Myrheim

Fors, Ane Schwenke
Investigations of aerosol optical depth in the ultraviolet and visible range above Trondheim. Instrumentation, intercomparisons and interpretations
Supervisor: Berit Kjeldstad

Haugen, Torgar
Preliminary magnetoresistive investigations of the coordination polymer Mn3 ((Hatp)2(atp)2)2 H20 4DEF)
Supervisor: Erik Wahlstrøm

Henden, Jan Håvar
Inhomogeneous Cosmology
Supervisor: Jan Myrheim

Jensen, Martin Bugge
Ion source experiments and simulations of extraction system and post-acceleration system for the CERN H-ion source.
Supervisor: Helge R. Skullerud

Jørgensen, Christian
The Gravitational Collapse of a Scalar Field
Supervisor: Jan Myrheim

Kyllingstad, Lars
Pion condensation in effective field theories
Supervisor: Jens Oluf Andersen

Marøy, Øystein
Lepton Flavour Violating Higgs Decays in a Minimal Supersymmetric Extension of the Standard Model
Supervisor: Kåre Olaussen

Meltzer, Marthe Marie
Detection of high energy neutralinos with neutrino telescopes
Supervisor: Michael Kachelriess

Sjøblom, Sara Johanna
Matter production in Quantum Field Theory with time-dependent parameters
Supervisor: Kåre Olaussen

Master of Science in Condensed Matter Physics and Biophysics

Kivambe, Maulid Mohamed
Electron microscopy and microanalysis of multicrystalline silicon solar and solar cell materials
Supervisor: Randi Holmestad

Kwarikunda, Nicholas
Solar Ultraviolet Radiation in Trondheim and Kampala. Based on Ground Measurements, Satellite data and Modelling
Supervisor: Berit Kjeldstad

Pantha, Nurapati
Surface UV Radiations in Nepal (Ground based measurements, Satellite information and Modelling)
Supervisor: Berit Kjeldstad

Master of Science in Natural Science Education

Henriksen, Sunniva
Medical physics - development, implementation and evaluation of a teaching sequence for upper secondary school
Supervisor: Berit Bungum

THESES - DOCTORAL STUDIES

Bakke, Jan Øystein Haavig
Universality of fracture roughness: a numerical study of lattice models for disordered media
Supervisor: Alex Hansen

Bhattarai, Binod Kumar
Factors affecting solar ultraviolet radiation. (Based on some case studies in Norway and Nepal)
Supervisor: Berit Kjeldstad

Juel, Mari
Properties of novel bimetallic surface structures
Supervisor: Steinar Raaen

Løseth, Lars Ole
Modelling of Controlled Source Electromagnetic Data
Supervisor: Ola Hunderi

Ramstad, Thomas
Steady-state two-phase porous flow and brittle fracture: A numerical study
Supervisor: Alex Hansen

Straume, Aksel
Magnetic flux density measurements and mobilphone provocation studies
Supervisor: Anders Johnsson

PARTICIPATION IN COMMITTEES

Evaluation committees:

Borg, A.:
* Opponent for PhD defence of Øystein Prytz, Department of Physics, University of Oslo, September 2007.
* Opponent for Lic. Degree of Johann Adell, Chalmers University of Technology, September 2007.
* Opponent for PhD defence of Mayandi Jeyanthinath, Department of Physics, University of Oslo, December 2007.
* Evaluation committee for appointing university lecturer in measurement technology at Department of Physics, University of Bergen.

Davies, C. de L.:
* Opponent for PhD defence, Tine Veronica Karlsen, Dept. of Biomedicine, Univ. of Bergen, January 2007
* Opponent for PhD defence, Sylvie G.D. Lelu, School of Pharmacy and Pharmaceutical Sciences, Univ. of Manchester
* Evaluation committee, Åste Søvik, Dept of Medical Physics, The Norwegian Radium Hospital/ Univ. of Oslo.

Holmestad, R.:
* Administrator for PhD defence of Mari Juel.

Kildemo, M.:
* Opponent and "Rapporteur" for PhD defence of Makrina Anastasiadou, "Imagerie Polari-métrique: Développements Instrumentaux et Applications Biomédicales," Laboratoire de Physique des Couches Minces et des Interfaces (LPICM), Ecole Polytechnique (France), December 2007.

Holmestad, R.:
* Administrator for PhD defence of Mari Juel.

Johnsson, A.:
* Opponent at PhD defence Melinda K. Christensen, University of Stavanger April 2007

Skagerstam, B.S.:
* Opponent for a Degree of Licentiate of Engineering defence of Lars Tornberg, Chalmers University of Technology, Göteborg, Sweden, 7/11, 2007.
* Administrator for PhD defence of Thomas Ramstad.
* Administrator for PhD defence of Jan Øystein Haavig Bakke.

A. Sudbø:
*Member of PhD Evaluation Committee for Marios Nikolaou, Kungliga Tekniska Høgskolan, Stockholm, March 2007.

Valberg, A.:
* Evaluation committee for professor competence of 1 candidate in Lighting Engineering, Høgskolen i Oslo.

International committees

Borg, A.:
* Member of the "Beredningsgrupp 2" under the Committee of Research Infrastructure (KFI), The Swedish Research Council, Sweden.
* Member of the IUPAP (International Union of Pure and Applied Physics) Working Group on Women in Physics.
* Member of the Evaluation committee on Physics and Astronomy as part of the "Quality and Renewal 2007, An Overall Evaluation of Research at Uppsala University", Uppsala University, 2007
* Member of the program committee of 6th Nordic Conference on Surface Science, Stockholm, Sweden, June 2007.
* Member of the Nordic Committee of "Nordic Network on Women in Physics", 3. workshop, Lyngby, Denmark, August 2007.
* Member of the board of MAX-lab, Lund University, Sweden.

Bungum, B.:
* Editor of scientific journal NorDiNa (Nordic Studies in Science Education).
* Member of the board for the 9th Nordic Research Symposium on Science Education, Reykjavik June 2008.

Fossheim, K.:
*Co-organizer of the international conference "Road to Room Temperature Superconductivity" June 17-23, 2007
*Member, International Advisory Committee, Low Temperature Physics Conference LT25, Amsterdam August 6-13

Fossum, J. O.:
*Member of the scientific evaluation panel for research projects submitted in physics to the Science and Technology Foundation - Portugal (FCT - Fundacao para a Ciencia e a Tecnologia; Ministeiro Ciencia, Tecnologia e Ensino Superior, Portugal)

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).
*Member of the IUPAP's Working group on nanoscience (WG8).
*Member of the Scientific Advisory Board to the Center of Excellence in Computational systems Research, Helsinki University of Technology
*Member of the Editorial board of the European Journal of Physics
*Member of International Scientific Committee of CCP2007, Brussels.

Holmestad, R.:
* Member of the board of the Scandinavian Electron microscopy society, SCANDEM.

Hunderi, O.:
* Editorial board for scientific journals. Editorial Board, New Journal of Physics 2002-
* Member of the publication Council, The optical Society of America 2007-
* Member of the organising committee for EPIOPTICS 10, Erice, Italy, June 2008.
* Member of the organising committee for LPHYS 08, Trondheim, June 08.

Kachelriess, M.:
* Member of the steering committee of "ISAPP: International School on AstroParticle Physics European Doctorate School"

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

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

Samuelsen, E. J.:
* Nordsync representative in "Search Committee for Directors of Research" at the ESRF, Grenoble.

Stokke, B.T.:
* Editorial Advisory Board – Biopolymers (Wiley).
* Member of administrative group of NORDTEK.
* Member of Administrative Council of SEFI.
* Board of Directors, CESAER.

A. Sudbø:
*Steering Committee Member, European Science Foundation Network on Nanoscience and Engineering in Superconductivity (NES).

Valberg, A.:
* Norwegian Representative in Commission Internationale de l'Eclairage (CIE), Division I, Vision and Colour.
* Member of Tecnical Committee TC1-37 of the CIE.

National committees

Andersen, J.O.:
* Member of the board of the group for subatomic and astrophysics in the Norwegian Physical Society.

Borg, A.:
* President, Norwegian Physical Society.
* Member of "Ressursfordelingskomiteen for tungregning", Research Council of Norway.
* Chair of "Programme for Synchrotron Research", Research Council of Norway.
* Member of the board of NTVA.

Brataas, A.:
* Member of "Ressursfordelingskomiteen for tungregning", Norwegian Research Council.

Bungum, B.:
* Member of the board for NAROM (Rådet for Nasjonalt senter for romrelatert opplæring).
* Member of the board for "Nasjonalt nettverk for naturfagutdanning" (National network for science education).

Davies, C. de L.:
* Node leader within the FUGEII supported nation network "Norwegian Molecular Imaging Consortium".

Fossheim, K.:
*Vice President of The Royal Norwegian Society of Sciences and Letters, 2005-2010
*Chairman of Jubilee Commitee of the 250th anniversary celebration of The Royal Norwegian Society of Sciences and Letters in 2010
*Chairman of two subcommittees under same.

Fossum, J. O.:
*Member of organizing commitee for The COMPLEX conference (Satelite conference to the Nanamat Conference) Bergen, Norway, June 8, 2007.

Holmestad, R.:
* Member of the board of UNINETT Sigma, dealing with high performance computing in Norway.

Johnsson, A.:
* Member of "Norsk Fysikkråd".
* Member project of steering group (Norwegian Defence Research Establishment) for project "Electromagnetic fields and human reproduction health" (Univ. of Bergen).

Kjeldstad, B.J.:
* Substitute member, Board of University of Svalbard
* Education committee for geophysical courses at University of Svalbard.
* Substitute member, Board of Sør Trøndelag University College, Faculty of Technology.

Reenaas, T.W.:
* Board member International Solar Energy Society Norway ("Solenergiforeningen").

Skagerstam, B.S..:
* Member of the Condensed Matter with Atomic Physics Division of the Norwegian Physical Society.
* Member of "Thorium-Utvalget" of the Norwegian Physical Society.

Stokke, B.T.:
* Chairman of the board, NANOMAT Research Program, The Norwegian Research Council
* Leader National council for technological education, The Norwegian Association of Higher Education Institutions.
* "Publiseringsutvalget", The Norwegian Association of Higher Education Institutions.

A. Sudbø:
*Member, National Working Group for FUNMAT.

University and Departmental committees

Borg, A.:
* Member of FUS ("Forvaltningsutvalget for sivilingeniørutdanningen") at NTNU.
* Vice dean on education, Faculty of Natural Sciences and Technology.
* Member of FUL ("Forvaltningsutvalget for Lærerutdanningen") at NTNU.
* Member of Educational Committee of NTNU
* Member, "Studieprogramråd for Lærerutdanningen i Realfag".

Brataas, A.:
* Chairman of the board of "Realfagsbiblioteket".

Bungum, B.:
* Member of the steering committee for TIGRIS – "Teknologi i grunnopplæringa i skolen".
* Member, "Studieprogramråd for Lærerutdanningen i Realfag".
* Chairman, Division of Applied Physics and Didactic Physics (January-April and November-December).
* Member of reference group for "Forum for Teknologi & Forskningslære" for teachers.

Davies, C.:
* Member of the leader group in strategic areas Medical Technology.
* Member of the program committee in Bioinformatics.
* Member in the program committee of Lørdagsuniversitetet.
* Member of "Formidlingsutvalget" at Dept. of physics.

Fossheim, K.:
* Chairman, "Formidlingsutvalget ved Institutt for fysikk".

Hansen, A.:
* Member, "Studieprogramråd for fysikk og matematikk".
* Elected member of Departmental Council.

Holmestad, R.:
* Chair/co-chair of the TEM Gemini Centre .
* Elected member of Departmental Council.
* Chairman, "Studieprogramråd for MSc Condensed Matter Physics and Biophysics".

Hunderi, O.:
* Chairman, Division of Condensed Matter Physics.
* Chairman, "Studieprogramråd for fysikk og matematikk".

Johnsson, A.:
* Member, board of the Faculty of Natural Science and Technology.
* Member of "Studieprogramrådet for Fysikk".
* Member of "Committee for institutional archive and open access", NTNU
* Member of "Committee for Space Science activities at NTNU".

Kjeldstad, B.:
* Head of the Department of Physics.

Lindgren, M.:
* Chairman, Division of Applied Physics and Didactic Physics
* Elected member of Departmental Council.
* Representant i studieprogramråd for fysikk og matematikk 2008-2010

Lindmo, T.:
* Chairman, Division of Biophysics and Medical Technology.
* Member, ”Studieprogramråd for fysikk og matematikk”.
* Chairman, “Studieprogramråd for MSc Medical Technology”.
*Director, “Strategic University Programme in Medical Technology”

Mikkelsen, A.:
* Chairman, Division of Complex Materials.

Olaussen, K.:
* Deputy Head of the Department of Physics.

Reenaas, T.W.:
* Member leader group “Senter for fornybar energi”
* Member, “Studieprogramråd for MSc Condensed Matter Physics and Biophysics”

Sikorski, P.:
* Acting chairman of detail planning committee for the bionanotechnology clean room, NTNU Nanolab.
* Member, Ledergruppen NTNU Nanolab.

Stokke, B.T.:
* Chairman of the board, NTNU Nanolab, NTNU.
* Dean of Engineering Education, NTNU; Chairman of the executive committee of engineering education, NTNU (FUS).

Støvneng, J.A.:
* Chairman, “Undervisningsutvalget ved institutt for fysikk”.

Sudbø, A.:
* Chairman, Division of Theoretical Physics.

Valberg, A.:
* Member of the board of the interdisciplinary Program for Master Studies in Neuroscience at NTNU.

Wahlstrøm, E.:
* Chairman, detail planning committee for the physical clean room, NTNU Nanolab.
* Member, ”Studieprogramråd for nanoteknologi”.
* Member, “Undervisningsutvalget” at the Department of Physics

Øverbø, I.:
* Chairman, ”Studieprogramrådet for Realfag”.

Arrangement committees:

Bungum, B.:
* Organizer of study trip for teachers to the ASE conference (Association for Science Education), Liverpool, January 2008.
* Organizer of in-service course for physics teachers, Trondheim, April 26-27.

Hansen, A.:
* Convenor of “Fredagskollokviet i fysikk”, Spring 2007.

Holmestad, R:
* Convenor of “Fredagskollokviet i fysikk”, Fall 2007.

Kachelriess, M.:
* Convenor of “Fredagskollokviet i fysikk”, Fall 2007.

Kjeldstad, B.:
* Scientific committee and chairman: One century of UV Radiation Research, Davos, Switzerland, 18-20 September 2007.
‘ Scientific committee: 34th Annual European meeting on Atmospheric Studies by Optical Methods, Andøya, Norway, August 26-31.

Lindgren, M.:
* Co-chairing the conference: Optical materials in defence systems technology. Part of the SPIE Symposium "Defence and Security" Firenze, 2007.

Skagerstam, B.-S.:
* Convenor of “Fredagskollokviet i fysikk”, Spring 2007.

FRIDAY COLLOQUIUM

"Fredagskollokviet i fysikk"

Convenors: Alex Hansen and Bo-Sture Skagerstam (spring)
Randi Holmestad and Michael Kachelriess (autumn)

Programme – spring term

5. January. Professor Helmer Fjellvåg, Senter for materialvitenskap og nanoteknologi, UiO:
Materials Studies at UiO by Means of Neutrons and Synchrotron X-Rays.

12. January. Professor Jon Magne Leinaas, Institutt for fysikk , UiO:
Black Holes, Unruh Effect and How Accelerated Electrons Get Hot.

19. January. Professor Jon Otto Fossum, Institutt for fysikk, NTNU:
How do Complex Phenomena Emerge from Simple Ingredients? Complex Matter Science by Example: Spontaneous and Guided Self-assembly of Nanoparticles.

26. January. Professor Thomas Tybell, Institutt for elektronik og telekommunikasjon, NTNU:
NTNU NanoLab: NTNU's Strategic Tool to Nanotechnology.

2. February. Professor Holger Bech Nielsen, Niels Bohr Institute, Copenhagen, Denmark:
Hunting for the Fundamental Laws of Nature.

9. February. Per Ivar Wethe, Institutt for energiteknikk - IFE, Kjeller:
Noen momenter om uranbasert kjernekraft – med et sideblikk på Thorium.

16. February. Professor Helge Redvald Skullerud, Institutt for fysikk, NTNU:
Forskningsfusk - isolerte hendelser eller utslag av massiv systemsvikt?

23. February. Professor Ola Hunderi, Institutt for fysikk, NTNU:
Plasmonics.

16. March. Professor Alan J. Kogut, Goddard Space Flight Center, NASA, U.S.A. :
The Biggest Picture: Cosmology and the Cosmic Microwave Background.

23. March. Postdoc. Roland Wittje, Institutt for fysikk, NTNU:
Physics at NTH 1910 - 1942: From a Teaching to a Research Institution.

30. March. Professor Johannes Falnes, Institutt for fysikk, NTNU:
Bølgjekraftforsking i bølgjegang ved universitetet i Trondheim gjennom eit tredjedels hundreår.

13. April. Professor Michael Kachelriess, Institutt for fysikk, NTNU:
Dark Matter in the Universe.

20. April. Professor George Bruun, Niels Bohr Institute, Copenhagen, Denmark , Copenhagen:
Cold Atomic Gases - A New Quantum System.

27. April. Professor Mattiehu H. Ernst, Institute of Theoretical Physics, University of Utrecht:
The Surprisingly Rich Behavior of Kinetic Equations for Dissipative Processes.

11. May. Professor Dr. Philos. Emil J. Samuelsen, Institutt for fysikk, NTNU:
"Central Modes" and Other Modes in Materials.

18. May, Professor Iver Brevik, Institutt for energi- og processteknik, NTNU:
The Casimir Effect: Past, Present and the Future.

Programme – autumn term

25. June. Ludwig Fadeev, Euler Institut, St. Petersburg:
The Mass Problem for the Yang-Mills Quantum Theory

17. August. Bikas Chakrabarti, Saha Institut for Nuclear Physics, Calcutta:
Economic Inequality: Is it Natural?

31. August. Ivar Svare, Institutt for fysikk, NTNU:
75 years 'Technical Physics' at NTH/NTNU

7. September. Per-Olof Nilsson, U Chalmers:
Scientific communication using physics toys

14. September. Steen Hansen, Dark Cosmology Center, Copenhagen:
Structure formation in the Universe

21. September. Dag Breiby, Institutt for fysikk, NTNU:
Functional materials studied by X-ray diffraction - What's new?

28. September. Anna Lipniacka, UiB:
From LEP to LHC: Shining light on the dark side of the Universe

5. October. Zhiliang Zhang , Dept. of Structural Engineering, NTNU:
NTNU Nanomechanical Lab and Nanomechanics Research

19. October. Anders Johnsson,, Institutt for fysikk, NTNU:
Plants in Space – some observations and challenges

26. October. Arne Braatas, Institutt for fysikk, NTNU:
On 2007's Nobel Prize in Physics for "giant magnetoresistance"

9. November. Bo-Sture Skagerstam, Institutt for fysikk, NTNU:
Photon Emission Near Superconducting Bodies

16. November. Robert Jaffe, MIT, Cambridge:
The Casimir Effect: Physical Manifestations of the Quantum Vaccum.

23. November. Elisa Resconi, Max-Planck-Institut für Kernphysik, Heidelberg:
High Energy Neutrino Astronomy: particle physics without accelerators or astrophysics without light?

Annual Report for Department of Physics 2007

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NTNU – Innovation and Creativity

The Norwegian University of Science and Technology (NTNU) in Trondheim represents academic eminence in technology and the natural sciences as well as in other academic disciplines ranging from the social sciences, the arts, medicine, architecture to fine arts. Cross-disciplinary cooperation results in ideas no one else has thought of, and creative solutions that change our daily lives.

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