2001

ANNUAL REPORT

complex **A SCIENCE PROGRAM IN NORWAY**

Complex Systems and Soft Materials

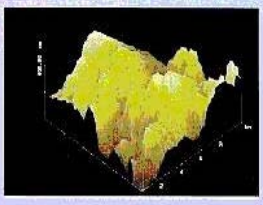
Most phenomena in our daily lives are governed by laws of the physichs. Usually we do not realize that ordinary daily objects, patterns and events are also complex physical systems.

A spider web is made of proteins and has a recognizable pattern, and is thus an example both of a soft material and a computable complex system.

Have you ever wondered what happens, during the prosess from natural clays to artistic clay? The shaping of wet clay is an example of complex physical phenomena: Why doesn`t the bowl in the picture above collapse? How can something (for example a piece of wet clay) apperently be a solid or a fluid just by the touch of a soft hand? Basic physics behind this inherent duality, and what may control it, is not understood.

A self organized bird flock represent another example of a complex system, whereas DNA represents complex systems and soft materials on molecular level:

Why does kethup flow only when you hit the bottle, while red wine or water flows by itself?



The upper photo is a piece of dried clay that measures 1/1000 millimeters on the side. The photo below is of the Himalayas and measures tens of kilometers. The size ratio between them is 10 billion.Suppose now that we move the snow and clouds to the upper photo and the strange colors and coordinate system to the lower photo. Are you sure that you would not mistake the clay for Himalayas and vice versa?

NTNU Norwegian University of Science and Technology

ife Institute for Energy Technology

Department of Physics
Norwegian University of
Science and Technology

NTNU

DEPARTMENT OF PHYSICS, NTNU

http://www.phys.ntnu.no

CONTENTS

Edited by:

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The Annual report is also available on the net at address:

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

Front page:
A presentation of one of the research areas that the Department of Physics is highlighting together with University of Oslo and Institute for Energy Technology

A SHORT HISTORY

The Norwegian University of Science and Technology (NTNU) in Trondheim has roots back to the Norwegian Institute of Technology (NTH) which was inaugurated in 1910 as the first institution in Norway to educate engineers at a scientific level. The task of the first professor of physics, S. Sæland (1874–1940), was to teach mechanics and applied physics, with small opportunities to do scientific research. S. Sæland was the first President of NTH, a member of the Norwegian parliament, and a successful research politician. He managed to strengthen the position of physics at NTH considerably by getting grants for a separate physics building which was completed in 1925. In 1922 a teacher's college (Norges Lærerhøgskole) was also inaugurated in Trondheim, and a lecturer position with teaching duties at this college was established at NTH.

In 1923 the young J. Holtsmark (1894-1975) took over the physics chair. As one of the first propagators of quantum mechanics in Norway he managed to establish a number of very different research activities. He is known for his work on the Stark-effect and the width of spectral lines, and on electron scattering (Holtsmark-Faxén formula). O. Devik, lecturer at the institute 1922 - 1932, was working in geophysics, mainly physics of the ice. Other notable research activities at the institute during the inter-war period were x-ray crystal analysis, technical acoustics, Raman spectroscopy and the construction of a Van de Graaff particle accelerator. This instrument marked the beginning of nuclear physics in Norway.

A number of chemistry students took their diploma thesis in physical chemistry at the physics institute, among these L. Onsager who later received the Nobel Prize for his work in theoretical chemistry and physics. Teaching and research assistants were recruited among chemical and electrical engineers. Some of these assistants managed to achieve important positions in the Norwegian industry. Others went into a scientific career. In 1942 Holtsmark was appointed professor of physics at the University of Oslo. Together with former assistants from Trondheim he came to dominate the academic physics environment in early post-war Norway.

The chair in Trondheim remained vacant until H. Wergeland was appointed in 1946. R. Tangen was appointed in experimental physics in 1948 and S. Westin in technical physics in 1949. S. Westin was a key person in the establishment of the Foundation of Scientific and Industrial Research (SINTEF) at NTH in 1950. The post-war period was characterised by a strong interest in technical physics, and by a steady growth in the research and teaching activity. The enrolment of students increased from 20 in 1961 to about 100 in 1999. The teachers' college also expanded during this period, and a separate physics department was established. Today, the two independent physics departments have merged into a single unity, the Department of Physics, NTNU

Instrument maker Thv. Reed demonstrating "Earth's formation according to Laplace" in a lecture om 20th. September 1915

THE DEPARTMENT TODAY

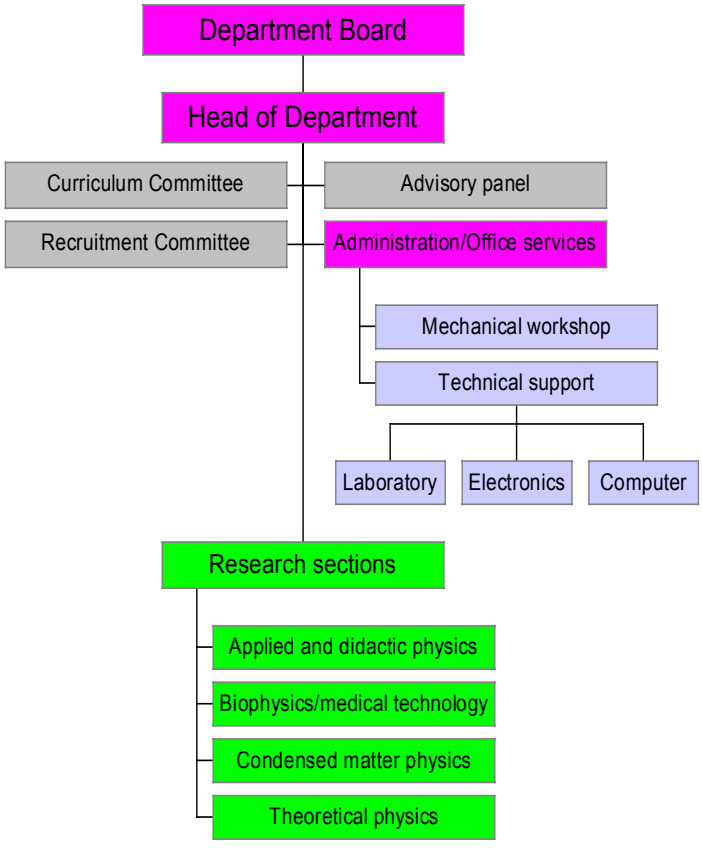
The main tasks of the Department of Physics at NTNU are to provide top quality education of undergraduates and graduate students and to perform research in physics at a high international level. A third important area is to provide the public and non-physics communities with popularized information on topics related to physics. All these tasks are interrelated. The overall goal is to ensure that society is provided with a work force of the highest standard.

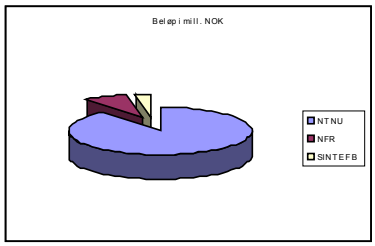
A major event for the Department has been moving into the new natural science building. This move required a considerable effort on the part of all the departments employees. Most of the year was characterized by the aftermath of these efforts and by initiating the adjustments necessary to fulfill all the requirements for an acceptable tuitional and research environment. Many of these adjustments continued well into 2001.

In 1999 a first version of a strategy plan for the department was written. The strategy process at NTNU requires that the plan should be revised on a yearly basis. An external evaluation committee was appointed in the fall of 1997. The committee consisted of national and international members from the physics community as well as from industry. This resulted in the evaluation report "*Physics at NTNU – in a decade of change*" which was ready at the end of 1998. The ideas and recommendations in this report were subsequently discussed in several internal subcommittees at the department. This resulted in a new strategy for the department. The research activities were divided into four sections: Applied and Didactic Physics, Biophysics and Medical Technology, Condensed Matter Physics and Theoretical Physics. The strategy plan for the department gives the following approximate distribution of scientific staff: 30% theoretical physics, 20% experimental biophysics and 50% experimental and applied physics.

Staff	**#**
Professors	34
Adjunct Professors	7
Associate professors	13
Techn./Admin. Staff	32
Researchers	7
Research Fellows	52
Student Assistents	120

Physics Department, NTNU





The sectors show the relative contributions from NTNU (46.721 mill. NOK), NFR (The Research Council of Norway; 4,118 mill. NOK) and SINTEF B (1.389 mill. NOK)

EDUCATIONAL PROFILE

Besides educating physisists for industry, business, research and schools, the Department is obligated to provide physics education to students from the technological faculties at NTNU. In addition to lecturing and problem-solving education in information technology and laboratory exercises are given. Especially the last two categories place a high demand on resources.

Education of physicists

In connection with the reorganization that took place during the establishment of a single university in Trondheim a new curriculum for the siv.ing. (graduate engineer) study in physics was initiated. From 1997 new courses were defined as 2.5 vt (credit points), and a full semester of study would then be 10 vt as is the case for other university studies in Norway. At the same time the siv.ing. study was expanded to last 5 years instead of 4.5 years.

A compulsory common course was introduced (5 vt) in the first year of study. For the students of physics and mathematics the curriculum in physics was reduced while that in mathematics was maintained. With this reduced curriculum general topics in physics are given on a basic level.

After 2 years of study the students can choose whether they will continue with physics or with mathematics. Those who choose physics have to take a series of compulsory physics courses during the 5th, 6th and 7th semesters. These courses have a broad basis, and they form a common foundation for continuing studies in one of the various directions that physics can offer. Two of the courses in these semesters, however, are chosen by the student. Biophysics offers courses that are specific for this branch of study.

Semesters 8 and 9 consist of a combination of project work and regular courses. In the latter it is possible to specialize based on a suggested combination of topics and to a certain extent on topics of the students own choice

The Department is in the process of coordinating the siv.ing. curriculum and the standard university curriculum. In this way both siv.ing. students and cand.scient. students are given the benefit of all physics courses available.

A survey of the curriculum is given on page 29, and a survey of theses delivered in 2001 is shown on page 23.

Doctoral study

Students who have obtained their siv.ing. degree can start to qualify for a dr.ing. degree. Students who have obtained their cand.scient. degree have a corresponding opportunity til qualify for the dr.scient degree. The effective study time to obtain the doctoral degree is stipulated to be 3 years for which financial support is given. This is often extended by periods of 6 or 12 months, depending on external or internal NTNU funding.

A series of courses are given at the post-graduate level. These courses are commonly given each second year. Sometimes they will be given as self studies guided by the supervisor.

The Department of Physics is recognized for the high quality of its post-graduae study. Each year our doctoral students contribute a number of publications to reputed international journals. Our doctoral candidates represent the backbone of the scientific activity at the Department and are thus of invaluable importance.

At present there are relatively few doctoral students in physics. This situation arises after a period with a considerable number of doctoral students. For the Department of Physics it is of importance that this situation does not persist too long. The scarcity of doctoral students is thought to be related to the fact that, at present, it is relatively easy to obtain other, better paid, employment.

Education of engineering students

The Department of Physics carries out an extensive education of students from various technology departments at NTNU. This. education consists mainly of introductory physics courses. As a part of several of these courses the students have to do compulsory laboratory excercises. In 2001 around 1400 students took these courses

The Department of Physics intends to adjust the contents of these courses in accordance with the requirements of the faculties in question. The reorganization of the siv.ing. study

from 4.5 to 5 years has resulted in a considerable increase in the need for lecturers for these courses.

Laboratory education

Experimental study of physical phenomena is of crucial importance for all physicist students including those that later specialise in theory. Education in the laboratory contributes both to the understanding of physical phenomena and concepts connected to the laws of nature. Laboratory work is also an important supplement to the lectures. For students that want to specialise in technological or experimental directions, it is of special importance to become familiar with experimental equipment. Besides performing the experiments the laboratory education includes calculation of uncertainties, keeping a laboratory journal, and writing reports. The use of information technology is an important part of this education.

Laboratory teaching has, in the meantime, become very demanding on resources. About 9 - 10 man years from the scientific staff were required for this education in 2001. The major part of the obligatory work load, which forms part of the doctoral students' commitment to the Department, is designated to supervising this education. Furthermore a large part of the technical staff of the Department is used to build and maintain the experimental set-ups

International Master of Science Programme

The International Master of Science programme in Physics at NTNU is designed to train the student in a chosen field of physics and in scientific work and research. The programme is taught in English and streches over two years corresponding to 40 credit points including a thesis of 12 credit points.

The first year includes course work corresponding to 20 credit points at graduate level. During the second year the student chooses his/her area of specialization and takes courses and self study which are tailored to this area of specialization and to the theme of his/her thesis. The thesis is expected to contain some independant research, but can also be of purely expository nature.

To be admitted to the programme a student is required to have completed a Bachelor's degree of at least three years university study including at least one and a half years of physics.

The first four students to this programme were taken up in 1999. So far the Department has taken up 15 students. The first two students graduated in 2001

RESEARCH

DIVISION OF THEORETICAL PHYSICS

Research in theoretical physics is performed internationally on a broad basis upon a variety of fundamental problems, from pure speculation and abstract models, through simplified models that contain general and crucial basic properties of real systems and phenomena, to more direct pplications where knowledge and phenomena previously restricted to academic consideration have become relevant. The section for theoretical Physics at NTNU has carried out research in the broad fields of *Condensed Matter Physics, Statistical Physics and Quantum Physic*s. These contain several subfields with a large variety of topics for research. Previous groups at NTNU "*Gruppe for kondenserte mediers teori"* and "*Gruppe for astro- og partikkelfysikk"* have now merged into a single unit, "*Seksjon for teoretisk fysik*k". This is in accordance with the recommendations of the international committee which recently reviewed Norwegian physics on behalf of NFR

More specifically research has been focused on: Effective gauge theories of strongly correlated systems, and breakdown of Fermi liquid theory; Statistical methods as prognostic tools in cancer research; Statistical mechanics of fluids, lattice gases, and spin systems at thermal equilibrium; Applications of statistical mechanics to biological problems, in which investigtions on the molecular level using methods of statistical physics are increasingly important; Investigations of mesoscopic structures or nanostructures that are intermediate between the molecular microscopic and continuum macroscopic level of matter; Further investigations of Casimir or van der Waals forces that are basic attractive forces between atom and molecules; The dynamics of granular matter that is a mixture of particles that are of mesoscopic or macroscopic size; Research in the field of modern quantum optics towards cavity quantum electrodynamics, quantum computers and quantum information; Continuation of research on various aspects of classical field theories, relativistic quantum field theories, thermal quantum field theories and phase transitions with various applications in e.g. astroparticle physics; Further investigations on selected topics in astrophysics, in particular studies of compact objects like the structure of neutron stars, gamma ray bursts and various studies of the cosmological evolution.

Some examples of activities during 2001:

Statistical mechanical models are used to explain and describe the folding and unfolding of proteins and their measured heat capacities. (A. Bakk, A. Hansen, J. S. Høye, and K. Sneppen)

In the fields of quantum optics we have continued to study the interactions of atoms and the second-quantized electromagnetic field in a superconducting cavity. We have studied collective effects as well as effects of damping on entangled states using numerical simulations (in collaboration with B.Å. Bergsjordet). A curious relationship between loop-group representations of non-compact groups and the physics of optical fibres has also been studied. (B.-S. Skagerstam)

We study two-phase flow in porous media using a network model with biperiodic boundary conditions. That is, we have wrapped it around a torus (donut). We start simulations by placing wetting and non-wetting fluids in a layered structure orthogonal to the flow direction. We then let the system evolve. Typically, the layered structure is broken up into contorted blobs of either fluid. In this topology, there is no longer any global distinction between drainage (where a non-wetting fluid displaces a wetting fluid) and imbibition (were a wetting fluid displaces a non-wetting one). These concepts only survive on the pore level. After some time, the system settles in a steady state. We study the properties of this state - which is a close approximation to what happens in a representative volume element deep inside a reservoir and far away from any boundaries. The networks we study are both two and three-dimensional – which means that our network forms the three-dimensional surface of a four-dimensional torus.

Professor Alex Hansen
Professor Eivind Hiis Hauge
Professor Per Chr. Hemmer
Professor Johan S.Høye
Professor Hans Kolbenstvedt
Professor Kjell Mork
Professor Jan Myrheim
Professor Kåre Olaussen
Professor B.S.Skegerstam
Professor Kim Sneppen
Professor Asle Sudbø
Ass. Professor S.Waldenstrøm
Professor Erlend Østgaard
Ass. Professor Ingjald Øverbø
Professor Emeritus Haakon Olsen

Our main results so far is to identify two differential equations that describe the flow. Solving these two equations, we are able to correctly predict the average flow properties of the system with respect to each of the two fluids. This work is done in collaboration with Prof. K.J. Måløy's experimental group at the Univ. of Oslo. (H. A. Knudsen and A. Hansen)

It is now a well established fact that brittle fracture surfaces have certain scaling properties known as self-affinity. Furthermore, there is overwhelming evidence that the scaling exponent associated with these scaling properties are universal in the sense that they do not depend on the material that has fractured for a large class of materials. It is still a mystery why the scaling exponent has the precise value it turns out to have. We are in collaboration with Prof. Måløy in Oslo and Dr. J. Schmittbuhl at the Ecole Normale Supérieure in Paris studying this problem both numerically, analytically and experimentally. (A. Hansen)

Lars Onsager showed how a system of long hard macromolecules, e.g. the tobacco mosaic virus, with increasing density have a phase transition to a nematic phase in which the molecules have a preferred direction. For a binary mixture of such molecules several additional types of phase transitions have been discovered, e.g. transitions between two phases both with isotropically distributed directions, and also between two nematic phases. Work in progress aims to determine for which diameter and length ratios of the two components the topologically different phase diagrams occur. (P.C. Hemmer)

The SCOZA (self-consistent Ornstein-Zernike approximation), which has turned out to yield very accurate equations of state for fluids and lattice gases, is further investigated. This, like the earlier development of SCOZA and evaluation of previous results in this respect, is done in collaboration with George Stell (Stony Brook University, New York) and others. Then new situations like simple models for fluids consisting of polymers are considered. A specific feature of polymer fluids is the very asymmetric phase diagram with critical point at very low density. (J. S. Høye)

The Casimir effect is further studied using methods developed for classical polarizable fluids. In this respect these latter methods have shown very powerful. The usual interpretation is that the Casimir force between two dielectric media or two metal plates are due to their influence upon and thus change of ground state energies of the quantized electromagnetic field. Together with I. Brevik (NTNU) we have found that the Casimir effect also can be interpreted as an induced interaction due to the quantized thermal fluctuations of polarizable particles or media interacting via the radiating electromagnetic field. (J. S. Høye)

In the field of theoretical high energy physics/quantum field theory the following topics have been investigated: Supersymmetry and the behaviour of running coupling constants in field theory with supersymmetric particles, the role of Dirac, Majorana and Dirac-Majorana particles in the renormalization group equations for coupling constants at one- and two-loop levels. Delbrück scattering. (K. Mork and I. Øverbø)

A theme is fundamental quantum mechanics, related to low dimensional systems, quantum computation and quantum information. The concept of quantum entanglement has been studied which may lead to a new insight concerning the relation between quantum and classical physics. (J. Myrheim, K. Olaussen in collaboration with J.M. Leinaas at University of Oslo and Raymond Chao at Berkeley)

Work on the flares in Accretion Disks around stellar mass black holes showed that the nano-flares contribute a small amount of intensity to the X-ray pulses. Further work applying to the supermassive black holes at the centre of active galactic nuclei is in progress. The role of Alfven Drag in the planetary magnetospheres, especially around the Earth and Jupiter are being investigated. It has been found that the effect is specially important for the small bodies weighing a tonne or below. It has been shown that some Craters like the Barringer Crater in Arizona and the Lonar Crater in India may have been possible due to the Alfven drag on the Earth's magnetosphere. The cratering on the

Jovian satellites is being investigated at present. Work has been started to make use of the spectroscopic observations of distant quasars combined with the observed cosmic background radiation anisotropies to derive possible constraints on the fundamental constants (partly in collaboration with B.-S. Skagerstam). Work to interpret the observations of living cells at stratospheric heights measured in 2001 January by a Ballon flight over Hyderabad,India, is also in progress. (S. Ramadurai)

Molecular networks guide the life of a living cell on multiple levels: its metabolic and signaling pathways are shaped by the network of interacting proteins, whose production, in their turn, is controlled by the genetic regulatory network. We study these networks from the control of the single genes, to large scale topology of signalling networks in living cells. This in particular include projects on 1) Experiment and modelling of genetic expression of repressor proteins in the phage system. 2) Models of small interconnected signalling and production network, including the heat shock network in E.coli and the P53 apoptosis network in human cells. 3) Analyze large scale topology of known signalling networks in yeast with respect to soft modularity, and with respect to possible interplay between expression levels and functional characterization of involved proteins. Finally we aim at developing evolutionary rules which are consistent with properties of observed networks, perhaps building a link between network evolution and species evolution. An overall theme is to use the requirement of robustness as an evolutionary principle. Other biophysical projects include protein folding studies, where we consider the interplay between the native state and the folding path leading to this native state. Also we model the possible structures of folded polymers, with constraints given by solely by hydrogen bonding. Finally we speculate whether a mechanical device on nano scale must be build from polymers, and thus whether protein like assemblies are the only possible machinery that one could build at that scale. Arguments for a 1-d backbone for nano machines include advantages related to 1) the subdivision of manufacturing into a coding part a assembling part, 2) leaving it to the 1-d backbone to maintain identity of parts while functional details can be taken care of by weaker cross links and 3) the inherent flexibility of polymers that would allow the machinery to grade its moves. (K. Sneppen and A. Hansen)

Strongly correlated systems in low dimensions are investigated using mapping to effective gauge-theories, i.e. local-symmetry theories of real (Z_2) or complex (U(1)) matter fields coupled minimally to compact gauge fields. Such field theories in principle have the potential for exhibiting confinement-deconfinement transitions. We have initiated a systematic study of such gauge-theories of Z_2/ Z_2 - and U(1)/U(1)-structure, as well as mixed structure using large-scale Monte Carlo simulations. The purpose is to investigate under what circumstance they show CD-transitions, if other phases than confinement/Higgs and deconfinement (Coulomb) phases can exist, and indeed what gauge-invariant quantities (order parameters) are meaningful when matter-fields are present. Interpretation of the phase-diagrams in the context of the underlying fermion theories is also a major challenge, among them relating the putative phase-transitions in the gauge-theories to a possible breakdown of Fermi-liquid theory. (A. Sudbø, in collaboration with H. Kleinert and F. S. Nogueira, FU Berlin, and J. Zaanen, University of Leiden)

- The massless limit of the effective action in quantum electrodynamics and chiral symmetry breaking, and photon detection theories. (B.-S. Skagerstam)
- Study of revival phenomena in simple quantum-mechanical systems. (S. Waldenström in collaboration with K. Mork and K. Naqvi).

National and international relations

The present staff has well established research collaborations with a large number of institutions, including *CERN, Chalmers University of Technology (CTH), Ecole Normale Supérieure (Paris), INLN-Université de Nice –Sophia Antipolis, Imperial College, Leiden University, NORDITA, Madrid Autonomous University, Max Planck*

Institute for Quantum Optics at Garching, Pennsylvenia State University, Polish Academy of Sciences at Warzaw, Royal Institute of Technology (KTH), State University of New York at Stony Brook, St. Petersburg State University, Tomsk Pedagogical University, TECHNION, University of Arizona at Tucson, University of Barcelona, University of Bergen, University of Copenhagen, University of Florida at Gainesville, University of Leiden, University of Napoli, University of Oklahoma, University of Oslo, University of Syracuse, University of Warsaw, Utrecht University.

The section is pleased to have had Prof. S. Ramadurai, Tata Institute, as a visiting professor in theoretical astrophysics during the fall of 2001. Prof. Ramaduari will continue his stay in our section until the end of 2002. The section has been honoured to have had a visit by Nobel Laureate Prof. G. 't Hooft during the celebration of the 100th anniversary of the Nobel Prize in December of 2001. Members of the section assisted in making the celebration programme at NTNU very successful, which attracted many of the younger generation.

Particle physics connected to big accelerators. (Haakon A. Olsen)

Central in my work is the theoretical studies connected to the experimental work at CERN and SLAC where gluons, quarcs and antiquarcs (the most "elementary" particles known today) are produced by collisions of extremely high energy electrons and positrons. In addition I study the theory related to the experimental work at DESY where electrons and protons collide in order to produce the same "elementary" particles.I have close contacts with the experimental and theoretical groups mentioned above for as long as these experiments have taken place. The joy of taking part in the finally successful development -which is shared with literally thousands of theoretical and experimental researchers - is the reward for sometimes hard work, doubtfulness and not always few failures.Sometimes the results besides providing new insight- go so far as to provide new questions and problems. Something new has been seen which was unknown before.It is thought provoking to find that already Goethe had a very precise feeling for these situations.In his poem Poemion he states:
Weite Welt und breites Leben
Langer fahre redlich streben,
Stets geforscht und stets begruendet,
Nie geschlossen,oft gegruendet,
Aeltestes bewarhrt mit Treue,
Freundlich aufgefasstes neue,
Heitern Sinn und reine Zwecke,
Nun,man kommt wohl eine Strecke!

It was Niels Bohr ,who called my attention to Goethe`spoem.I am in particular fond of :"Nun, man kommt wohl eine Strecke!".
Remarkably,Goethe describes in 1817 the future. Applied to current research, the poem states "Aeltestes bewahrt mit Treue",which is in accordance with modern correspondence principles.Further :"Freundlich aufgefasstes neue" -an impulse to accept new progress in science,for instance quantum theory,relativity theory and even present particle physics theory.
In relation to what I said above, I give brief descriptions of my current research:

QCD - Accelerator e(+) e(-) --- q q(bar) g physics.

I have in recent times been mostly concerned with two aspects of q q(bar) g-production.The effect of the quark mass and of quark and gluon polarizations. This is where SLAC does the best experiments:While CERN can produce overwhelming large quantities of particles in the circular accelerator,only SLAC can produce polarized quarks and antiquarks in the linear accelerator and keep them polarized.I have with my students for many years published papers mostly in Physical Review D..related to quark mass effects and to particle .polarization effects. It is rewarding that our results are being used in particular at SLAC for many years in connection with accurate experiments at the SLAC accelerator.The most recent ,published with my hovedfagstudent "Øyvind Kvam in Phys. Rev. D on gluon polarization effects is recorded under "Publications"in this annual report.

CP-violation in B-B(bar) processes.
The parity violation in weak interactions was discovered in the late

1950-ies,and led to a revolution in particle theory-which ultimately lead to the discovery of the electro-weak interaction,which in turn gave us - including QCD- our present theory of particle physics- commonly named standard model or better standard theory.But this was not the final story. In Phys.Rev.Letters 13,138 (1964) J.H.Christenson et al announced that they had shown that the CP-symmetry is violated under certain circumstances. C stands for "charge conjugation" as P stands for "parity operation". C changes particle to antiparticle (electron to positron),and P "Left-" to "Righthanded"- fairly acceptable definitions.It is most disturbing that there is no direct link between the two discoveries: P-transformation followed by C-transformation does not give CP-violation except under very special circumstances.The Ba Bar-experiments are being performed at SLAC, so I have have contact with BaBar. In fact my present work on CP-violation is a follow up of my resent Phys.Rev. gluon polarization paper. I try to see what effect a P-transformation has on the production amplitude.It is rather complicated due to the smallness of the effects.

Positronium beams
In the present publication on positronium beams I study electroproduction recorded under "Publications"in this annual report. The proposal to produce relativistic positronium beams was published by me in Phys. Rev. D 33 (1986). Subsequent publications on photo- and electroprodution are recorded in the present publication.The work on the proposal of the experiment at the Refer facility at The Hiroshima University is proceeding. In the present work I also study the production of polarized spin-1 positronium, which is a new feature.The calculation is exact i.e. it is valid also for heavy target nuclei.I expect together with my Russian and Japanize collaborators to be able to see results from the experimental work in the near future.

Supersymmetry masses from the anomalous magnetic moment of leptons.
The present work on supersymmetry was started with a work published in Physica Scripta by Olaf F.Syljuåsen and Haakon A.Olsen, Vol.48,525,1993

Based on available data we obtained mass limits on smuons and photinos which were in agreement with results obtained by other theoretical groups. A new and considerably more precise experiment was announced , E821 at Brookhaven National Laboratory, which was assumed to improve the experimental limit, as we said in our publication.
In the meantime Ingve Simonsen wrote a very useful "hovedfagsarbeide" which is an excellent starting point for the analysis of the Brookhaven experiment which has been published resently. We are at present working on the publication related to the Brookhaven results, whenever we find time to do the work.

DIVISION OF BIOPHYSICS AND MEDICAL TECHNOLOGY

Professor Catharina Davies
Professor Arnljot Elgsæter
Professor Anders Johnsson
Professor Tore Lindmo
Professor Thor Bernt Melø
Ass. Professor A. Mikkelsen
Professor Kalbe R.Naqvi
Professor Bjørn T.Stokke
Professor Arne Valberg

This division comprises nine scientific staff and also represents a wide activity in different fields of Biophysics and Medical Technology. The research interests span from molecular studies in, for example, the DNA and carotenoid field, covers an activity in biopolymers, spectroscopy in photobiophysics and research on the human visual system etc.

We have chosen to describe a few of these projects in length. Future annual reports will be used to complement descriptions of our activities.

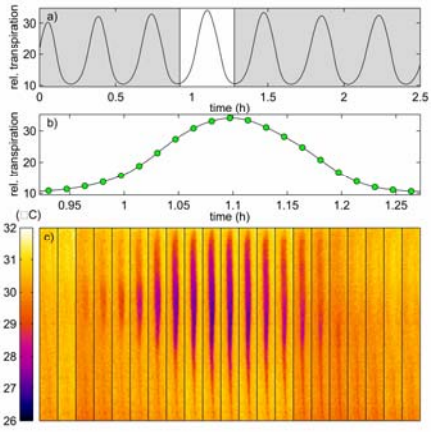
Water regulation of plants

(Research by Professor Anders Johnsson)

During 2001 new results have been achieved in the project to study water regulation of plants.
An experimental set up has been built that allows simultaneous recording of water transpiration, water uptake and CO_2 uptake by single plant leaves. Under special circumstances the water transpiration can start to oscillate with a typical period of about 40-min at room temperature. The water pathway through the plant has been modeled in the project.

Such oscillations reflect the volume oscillations in special guard cells of the leaf surface. The guard cells control the water transpiration as well as the carbon dioxide uptake of the leaf for photosynthesis. They are thus the crucial regulatory units of the water regulation as well as the carbon dioxide regulation.

In the project the nature of the oscillations were studied. A particular method allowed the supply of ions to the guard cells and widely different periodic transpiration could be induced. Simultaneously the temperature of the leaf surface was monitored by IR camera techniques and it was demonstrated that the guard cells under most conditions were synchronously oscillating over the leaf surface. Under special conditions the guard cells could open over parts of the leaf, thus creating waves of water transpiration (an thus temperature lowering) over the surface. These oscillations – in time and over the leaf surface – were a central topic in the doctoral thesis by G. Prytz in November 2001.



The two uppermost figures show the transpiration from a single, young oat leaf with two different time scales (the white section in upper figure "exploded" in the middle figure). In the middle figure the dots indicate when IR camera pictures were taken (about 1 min apart). In the lowermost figure, each picture section shows the successive temperature distribution (scale to the left) along the oat leaf, from base to top. It has evidently lower temperature when the transpiration is high but transpiration occurs firstly and mostly in the middle section of the leaf.

Transport of therapeutic macromolecules in tumour tissue

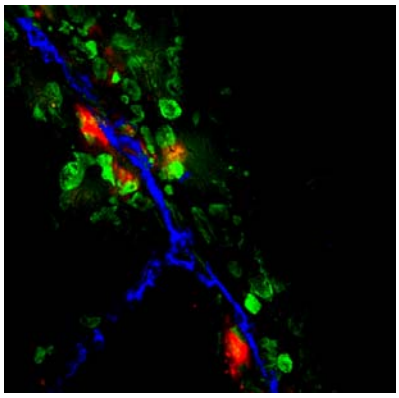
(Research by Professor Catharina Davies)

Tumour selective cancer therapy is based on large therapeutic molecules such as monoclonal antibodies carrying radioactive isotopes, toxins or drugs, DNA vectors carrying therapeutic gene (gene therapy), or liposomes carrying drugs. These molecules have a diameter in the order of 10 to 10.00 nm and have therefore great difficulties reaching the tumour cells. The mechanisms of transportation are diffusion and convection governed by the concentration- and pressure gradient, respectively.

In 2001 we have studied and published on the uptake and distribution of liposomal doxorubicin in

osteosarcoma xenografts growing in athymic mice. The aim was to see if ionising radiation or the enzyme hyaluronidase improved the uptake and distribution of liposomal doxorubicin. Our new confocal laser scanning microscope (Zeiss LSM510) was used for three colour imaging of intact liposome, doxorubicin released from the liposomes, and blood vessels. The tissue distribution of doxorubicin and colocalisation relative to blood vessels were studied (see figure).

The high interstitial fluid pressure which is approximately equal to the microvascular pressure, is the main reason for poor penetration of macromolecules. Dr.ing. student Live Eikenes showed that the enzyme collagenase reduces the interstitial fluid pressure and the microvascular pressure, and the kinetics in the IFP and MVP response differed, introducing a transient transcapillar pressure gradient. Consistent with this, a two fold increase in the uptake of monoclonal antibody binding to osteosarcomas was found.



Liposomes (red) are located close to the blood vessels (blue). Doxorubicin (green) released from the liposomes has penetrated a short distance from the vessels. The high interstitial fluid pressure and low diffusion coefficient for large molecules, impede penetration into the extracellular matrix.

DIVISION OF CONDENSED MATTER PHYSICS

Professor Anne Borg
Professor Johannes Bremer
Professor Kristian Fossheim
Ass. Professor Jon O.Fossum
Professor Randi Holmestad
Professor Ola Hunderi
Professor Ragnvald Høier
Professor Frode Mo
Professor Steinar Raaen
Professor Emil J.Samuelsen
Ass.Professor Bård Tøtdal
Professor Emeritus Ivar Svare

Polymers and molecular organic semiconductors

The research focuses on organic semiconductors/conducting polymers like poly-thiophenes and -anilines, and partially conjugated materials, using diffraction and spectroscopic methods. Emphasis on low-dimensionality properties. Orientation effects of ultra.thin layers (10-200 nm) on solid and liquid substrates.

Transmission-electron microscopy

The research focuses mainly on quantitative electron diffraction, high resolution microscopy and spectroscopy methods, atomistic modelling and ab initio methods in materials science, TEM studies of new Al alloys, commercial Al- and Mg-alloys, TiAl intermetallics and high performance ceramics, to mention some. The group works in close collaboration with the Materials Physics group in SINTEF Applied Physics.

High-Tc superconductivity, experiments

The group has in the past worked on the structure, thermodynamics and flux line dynamics in a number of high-Tc compounds. Presently the elastic properties of the flux line system is being investigated by ultrasound, and the effect of critical fluctuations on thermodynamic properties is being studied.

Crystallography, methods and instrumentation

The major activity has been diffraction studies of polythene for investigating the influence of different processing conditions and polymer parameters on structure, crystallinity and crystalline block size, furthermore to study melting and solidification processes of the polymer. This work is a collaboration with two other Norwegian groups and with industry. All experiments were carried out at the Swiss-Norwegian Beam Lines at ESRF.

Diffraction studies of polyethylene

F. Mo

Polyethylene (PE) is a synthetic thermoplastic polymer consisting of crystalline regions embedded in an amorphous matrix, in addition there is some evidence for regions of intermediate order. The relative amount of the different phases is of crucial importance for the mechanical properties of the polymer and the microstructure and hence properties can be modified in the industrial process.
We have examined about 40 different samples of PE by X-ray diffraction for a range of purposes:
* to refine cell parameter and crystal structure in order to study the influence on the unit cell and chain packing by different processing conditions and properties of the polymer
* to determine crystallinity and mean crystalline block size in order to investigate correlation with various critical parameters such as: a) average molecular weight (M_n), b) molecular weight distribution or polydispersity (M_w/M_n ratio), and c) added amount of co-monomer (hexene)
* to study crystallinity, thermal expansion and possible phase transitions as a function of temperature (T increasing through T_{melt}) as well as a study of solidification and recrystallization processes (T decreasing through T_{melt}).
For the T dependent part eight samples have been subjected to temperature scans between 40 and 200 °C in steps of 10 °C, decreasing to 5 and finally to 2 and 1 °C in the actual melting or solidification ranges. Each T cycle involves from 30 - 50 diffraction exposures.
Diffraction images were generated with synchrotron radiation and collected on a 2-dimensional image plate with exposure times 30 sec or 120 sec depending on the beam flux. Readout and erasure times were typically in the range 1.5 - 2 min. With radiation from a conventional X-ray tube and photographic film as a detector a typical exposure time of 4 hrs. was required. Thus, without access to a synchrotron source and an image plate

detector this study could not have been carried out. The data obtained from the *T* cycles in particular contain a wealth of information on crystallinity, melting and recrystallization. Detailed analyses of the data are in progress.

This work is a collaboration with P.V. Hemmingsen and J. Løvland (Dept. of Chemical Engineering, NTNU) and K. Knudsen (IFE).

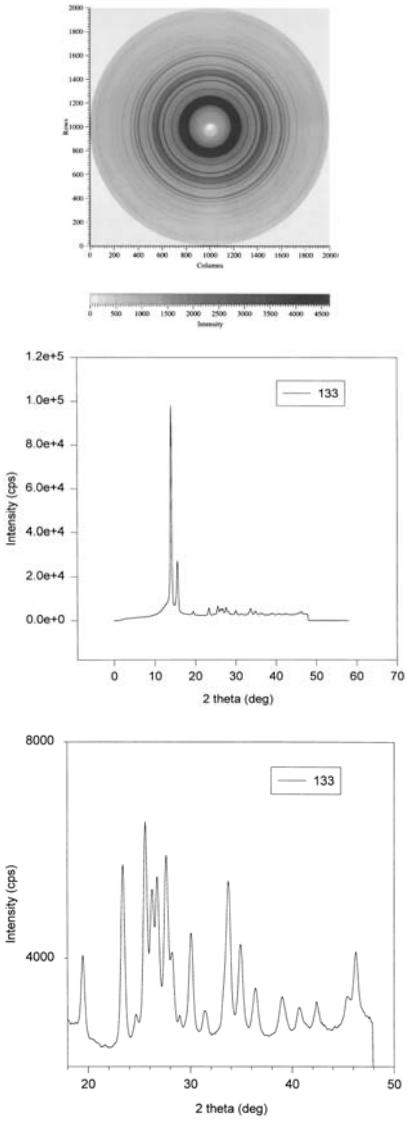


Fig. 1 A 10 s exposure of a PE sample with synchrotron radiation collected on a MAR 345 image plate.

Fig. 2 Diffraction rings on image plate integrated and depicted radially as a function of diffraction angle 2θ.

Fig. 3 Enlarged diffraction pattern for 2θ > 18°

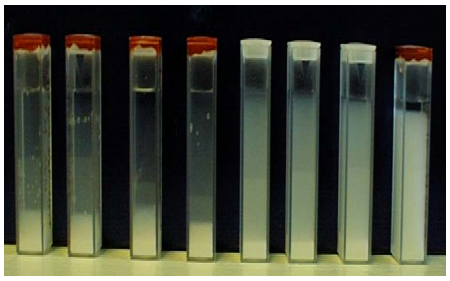
Soft condensed matter, complex materials

Complex Physical Phenomena in Synthetic Clays:

Clays represent a traditional material, whose applications include building materials, ceramics, rheology modification, catalysis, paper filling, oil well -drilling and -stability, etc.. Fundamental studies of complex physical phenomena of clays, and resulting applications of clays beyond traditional approaches and disciplines, are merely at its beginning, but with the increasing availability of clean chemistry customized synthetic clays, there is presently a growing scientific activity associated with including clays into modern materials science together with other and often generally better understood synthetic and complex adaptive materials such as colloids, polymers, liquid crystals, bio materials, etc.

Wet clays may on one hand be considered as aqueous suspensions of physical colloids made up of interacting platelet shaped primary particles. Numerous gel and sol phases are possible, along with the possibility of liquid crystalline ordering, although evidence for the latter in clay colloids has been ambiguous so far. On the other hand, dry clays may be viewed as intercalation compounds, and it is in this context of basic importance to integrate clays into the specific and universal physics of other intercalation compounds and "nano sandwhiches" One prominent example of our activities within this context during years 2000-2001 include synchrotron X-ray diffraction experiments which were performed using the liquid surface spectrometer at Argonne National Laboratory's CMC-CAT Beamline 9IDC. We studied gravity dispersed solutions of synthetic swelling Na-fluorohectorite clay over a large salt (NaCl) concentration range. Our novel use of liquid scattering techniques allowed us to identify regions in which particles reorient from horizontal to vertical alignments in phases coexisting at different heights within stratified samples. We in this manner for the first time established the existence of distinct nematic and isotropic phases in a system of screened charged platelets. Main collaborators include: E. DiMasi, Brookhaven National Laboratory, T.

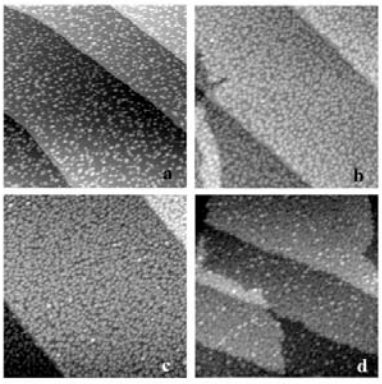
Gog and C. Venkataraman, Argonne National Laboratory.
Below: Image of gravity dispersed phases in the platelet silicate system (synthetic Na fluoro hectorite clay). Increasing salt contents from left to right.



Ongoing work. One publication in 2001: "Orientational order in gravity dispersed clay colloids: A synchroton x-ray scattering study of Na fluorohectorite suspensions", E. DiMasi, J.O. Fossum, T. Gog and C. Venkataraman, Phys. Rev. E, 64, 061704-1 (2001).

Surface physics

The main areas of research are studies by use of surface analytical tools of metallic systems that are of potential interest to catalytic processes. Magnetooptical properties of materials are also studied through the interaction between these properties and surface plasmons. The main experimental techniques include scanning tunneling microscopy (STM), photoelectron spectroscopy, Low energy electron diffraction (LEED), temperature programmed desorption (TPD), ellipsometry, reflection anisotropy spectroscopy as well as infrared spectroscopy and light scattering experiments.



Re island growth on Pt(111)

Vibrational fine structure of molecular adsorpates on surfaces

In recent years, due to improved instrumental resolution at synchrotron radiation sources, it has been possible to observe additional fine structure in photoemission core level spectra due to internal molecular vibrations in molecules chemisorbed on well-defined single crystal surfaces. The vibrational fine structure observed in these spectra is due to vibrational excitations of the core ionized molecules leading to different vibrational frequencies as compared to observations by e.g. infrared spectroscopy.

The vibrational fine structure in the C 1s core level spectra of CO molecules adsorbed on the single crystal surfaces Co(0001) and Rh(100) has been studied. As an example of such a vibrational progression, the C1s core-level spectrum of CO adsorbed in on-top sites on Co(0001) is displayed in the figure below. The C 1s core level spectrum is decomposed using standard decomposition procedures. The peaks at 285.89 eV, 286.11 eV and 286.33 eV (marked with arrows in the figure) are shown to originate from excitation of the first, second and third harmonic CO stretch vibrations, respectively. From the experimental data the vibrational frequencies for CO on Co(0001) and Rh(100) and the changes in the equilibrium distances in the molecules have been determined.

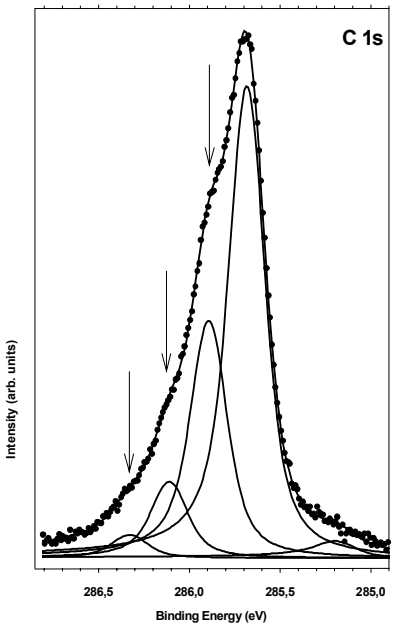


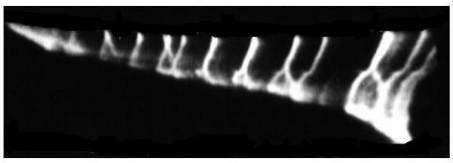
Figure: Normal emission C 1s photoelectron spectrum from the Co(0001)-(√3×√3)R30°-CO overlayer, recorded at a photon energy of 321 eV. Filled circles: experimental data, lines: individual components of the decomposition and the resulting fit for the adsorbate spectrum.

Similar experiments have been performed for acetylene on Co(0001). From acetylene gas phase data it is expected that the vibrational contributions to the C1s core level spectrum for adsorbed C_2H_2 are very weak. However, when acetylene is chemisorbed on Co(0001) significant contributions to the photoemission line are found which can be identified as vibrational contributions through comparison with data for the deuterated counterpart of acetylene, C_2D_2. A possible explanation for this finding is that upon adsorption on the Co(0001) surface the hybridisation of acetylene is altered from sp to near sp^3. This change in hybridisation may in turn affects the vibrational contributions to the spectra.

These experimental studies are quite fundamental in nature and contribute to the basic understanding of different contributions to high-resolution photoemission spectra.

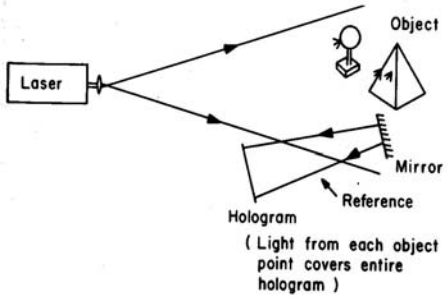
DIVISION OF APPLIED AND DIDATIC PHYSICS

Electrical breakdown in fluids and gases
The research focuses on experimental investigations of corona discharges in gases and eletrical discharging in insulating fluids. One graduate student has just finished a doctoral degree in this group.



Transport in ionized gases
The research focuses on charge transport in weakly ionised gases, with emphasis on coupling to low energy ion-molecule collision processes. There are currently no graduate students associated with this activity.

Technical optics
The main areas of research are video holography, radiometry, and fibre optics interferometry. This activity currently has three graduate students. Two graduate students have recently graduated.



Physics education
Areas of research interest are education and physics education, with particular emphasis on the interaction between practical work and the student's perception of the nature of science. There is also an involvement in large scale performance assessment in science.

Energy from ocean waves
The research focuses on optimum operation of wave-energy converters. Due to the lack of funding a graduate student discontinued his dr.ing.-thesis work three years ago.

Professor Johannes Falnes
Associate Professor Berit Kjeldstad
Associate Professor Per M.Kind
Associate Professor M. Kringlebotn
Professor Ole J.Løkberg
Associate Professor J.Løvseth
Associate Professor Tore H.Løvaas
Professor Hans M.Pedersen
Professor R.Svein Sigmond
Professor Helge Skullerud
Associate Professor T.Stefansson
Associate Professor Kåre Stegavik
Associate Professor Knut A.Strand
Emeritus Professor Reidar Nydal

Physics of the ear
Main focus is on experimental investigations of the physical properties of the human ear.

Light scattering from interfaces
The research focuses on determining viscosity for and interface tension between gases and their condensates under reservoir conditions.

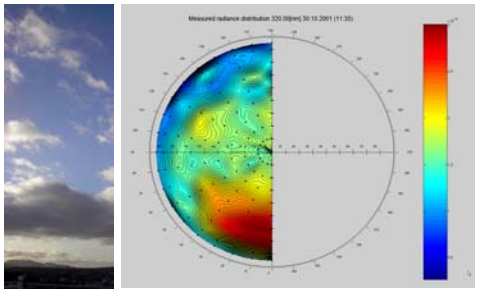
Effects of ultraviolet radiation
The topics of interest have been within environmental physics, with emphasis on changes in ultraviolet radiation (UV) in nature, both in terrestrial and marine environment. The research activities have been focused on instrumentation and methods related to quality control of UV measurements, and finally studies of the processes influencing radiation transfer in the atmosphere and the ocean.

Ultraviolet radiation in nature.

Ultraviolet radiation (UV, 280-400 nm) is an important environmental regulating factor for both terrestrial and aquatic life. The amount of UV radiation reaching the earth is strongly affected by the atmosphere and components as ozone clouds, aerosols but also reflection properties of the ground for instance extend of snow covered surfaces. Ultraviolet radiation is the main driving force of tropospheric photochemistry taking place at the lowest 10 km of the atmosphere. The radiation field itself is strongly modulated especially by clouds and aerosols. Considering that approximately 60% of the globe is constantly covered by clouds, a quantitative understanding of the radiation field is thus only possible with a detailed knowledge of the interaction of clouds with radiation.

Equipment has been developed at the department to measure UV radiation field at different atmospheric conditions. Spectral sky distribution can be measured in the range of 300 – 500 nm and sky maps can be obtained for different atmospheric conditions. Measurements can be compared with improved 3D-models both for clear sky conditions and scattered cloud conditions, which is a great challenge.

UV radiation is measured continuously at the roof of Realfagbygget with different equipment. There are ongoing projects to develop methods for data quality and data control.



Picture:
Scattered cloud conditions shown to the left.
Radiance at 320 nm (field of view 1.5°).
Measurements are obtain with a Bentham DM150 spectraradiometer and a suntracker developed at the department.

Alternative energy sources
The topics of interest are alternative energy sources and environmental Physics, Wind (both theoretical and experimental) and solar energy (with emphasis on focused solar systems) in close collaboration with University of Durban, South Africa.

Radiocarbon Reasearch
The research has mainly been concerned with penetration of bomb-radiocarbon (C14) into the ocean of the Barentz Sea. A common paper was at the end of the year published in the journal RADIOCARBON.(See below). According to Fig. 3 the paper consists f.i. of a complete time- series of C14 in Arcto-Norwegian cod otoliths in the period 1920 to 1995. The material was provided by the Institute of Marine Research in Bergen. The curve shows a fairly stable level from 1920 until an increase of C14 from nuclear tests occurs in 1950 The bomb peak reaches its maximum (in percent above normal level) in about 1970, and then the curve decreases gradually with time as a result of the Bomb Test Treaty of

1963. This treaty made en end of nuclear tests in the atmosphere, ocean and the outer space. The curve is an important tool in the study of carbon exchange between the atmosphere and the Nordic Seas

Reference:
Kalish, J.M (Canberra), Nydal, R.(Trondheim), Nedreaas, K.H.(Bergen), Burr, G.S.(Arizona), Eine, G.L.(Trondheim) 2001 : Time History of Pre- and Post-Bomb Radiocarbon in the Barents Sea Derived from Arcto-Norwegian Cod Otoliths. RADIOCARBON, v.43, No.2b part 2, p. 843-855

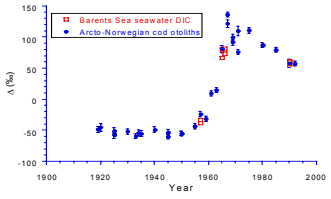


Figure 3. Radiocarbon data (Δ: percent above normal level) obtained from Arcto-Norwegian cod otoliths (this study) and Barents Sea seawater (Østlund and Engstrand 1963; Nydal et al. 1991,1998)

AWARDS AND MERITS FOR OUTSTANDING RESEARCH

Research Award to Professor Anders Johnsson

The Royal Physiographic Society in Lund has given its 2001 Linné award in Botany to professor Anders Johnsson at the Department of Physics. The award recognizes "outstanding research on plants and their rhythms, their photobiology, water regulation and orientation in the field of gravity". The prize of SEK 360 000 and a diploma were presented to Anders Johnsson at a ceremony in Lund, Sweden, on December 3, 2001.

The following press release was sent out (translation from Swedish):

"Anders Johnsson studied physics at Lund University and obtained his doctoral degree in 1968 at the Department of Physics at Lund University. Already at that time he worked on biophysical problems within plant physiology. He investigates the mechanisms for biological clock control of leaf movements, the flowering processes etc. The clocks have normally a period of about a day and Anders Johnsson has studied such daily rhythms. By using short light pulses it has been possible to demonstrate that the biological clocks of plants can betopped and restarted. The interest in the action of gravity on growth processes has stimulated him to initiate and organize experiments in Spacelab. Together with colleagues from the US he has, furthermore, studied spiral growth movements in plants on the earth as well as in weightlessness in space. He has also been responsible for Norwegian experiments in Spacelab – in which one has, e.g., studied the orientation of root growth in the absence of gravity.

In Anders Johnsson's research group other biophysical problems are also investigated: Problems related to photo reactions in bacteria, reactions of organisms to electromagnetic fields (also radiofrequency fields) and the biological clocks of Man"

Emeritus professor Haakon A.Olsen elected member of Central European Academy of Science and Art

"The Bureau of the Central European Academy of Science and Art,at the recommendation of the National Committees in each country,after long discussions, agreed with your nomination to become the member of honor of the C.E.A.S.A.

Taking into account your scientific work of European level,
Taking into account your contribution to the strengthening of the solidarity in the European academic community,
Taking into account your rich and original contribution to the development of
science,
The Bureau decided unanimously to accept this recommendation."

ITEMS AND EVENTS OF INTEREST

The Nobel Prize 100th Anniversary

As part of the celebration of the Nobel Prize 100th anniversary, the former Nobel Laureates in Physics, Professor Gerardus 't Hooft and Dr. Heinrich ohrer, visited the Department of Physics and NTNU December 2nd-5th.

Professor Gerardus 't Hooft from the Netherlands received the Nobel prize in Physics 1999 together with Prof. Em. Martinus J.G.Veltman for "elucidating the quantum structure of electroweak interactions in physics". Prof. 't Hooft gave seminars at NTNU bothfor a broader audience and for specialists in his field. The topics of the seminars were: "Asking Fundamental Questions in Elementary Particle Physics", "How does God Play Dice" and "Determinism and Reductionism in Science".

Dr. Heinrich Rohrer from Switzerland received the Nobel prize in Physics 1986 together with gerd Binnig for "their design of the scanning tunneling microscope". They share the prize with Ernst Ruska who received the prize "for his fundamental work in electron optics and for the design of the first electron microscope". Dr. Rohrer's work is connected to some aspects of nanotechnology and a special "Nanoscience Seminar" was arranged with Dr. Rohrer as the main speaker. The topic of his presentation was "The Magic of Small, Nanotechnology". Several other invited talks were given at the seminar: "Fabrication of 0- and 1-dimensional Structures and their use in Quantun Devices" by Prof. L. Samuelson, Sweden, "Spin Injection without magnetic element" by Prof. K.-A. Chao, Sweden, "A local look at Complex Oxides: Challenges and Possibilities" by Dr. T. Tybell, Switzerland and "Nanoscale Biopolymer Assembly; Stretching and Interactions" by Prof. B.T.Stokke, Norway.

Both former Nobel Laureates in Physics took part in the other Nobel prize 100th Anniversary events arranged by NTNU during their visit.

Annual Meeting of the Norwegian Physical Society 2001

Department of Physics, NTNU hosted The Annual Meeting of the Norwegian Physical Society 2001. The meeting took place June 14th-17th. The 2001 Annual Meeting was the first in a new series of larger Physical Society Annual Meetings including sessions for the seven different sections of Norwegian Physical Society. It attracted nearly 200 participants, including Norwegian physicists and invited speakers from all over the world.

Parallel sessions, including invited and contributed talks, with section specific program constituted the main part of the meeting. In addition invited speakers, suggested from the different sections, gave plenary presentations. The plenary sessions covered a variety of topics: "The long-term drift in coronal Source flux: origins and implications" by Prof. M.Lockwood, United Kingdom, "Medical imaging by ultrasound: some future challenges" by Prof. K.A.Ingebrigtsen, Norway, "The Universe: its birth and ultimate fate" by prof. K.Enqvist, Finland, "On Micromechanics of Cells" by prof. E. Sachmann, Germany, "Crack fronts and damages in some complex microstructures" by Dr. E. Bouchaud, France, "The Quantum World unveiled by Electron Waves" by Prof. A. Tonomura, Japan and "Computational Media and New Literacies: New Foundations for Thinking" by Prof. A.A. diSessa, USA. Two prizes were awarded at the meeting, the Education prize awarded to lektor Per Jerstad for his efforts in physics teaching and physics activities for his students and the SIMRAD Optronics Physics Prize awarded to researcher Jon Tschudi for his outstanding ability to utilize electrooptics for solving specific taske such as in trash sorting units. The meeting ended with the formal part of the Norwegian Physical Society Annual Meeting including elections and resolutions.

NFR Centers of Excellence

The Norwegian Reasearch Council NFR invited in year 2000 Norwegian Universities and Research Institutions to submit proposals for Centra of Excellence in Scientific Research. Forty of the sublitted proposals were selecyed to og on to the second round of evaluation. About ten of these will receive funding. This will be decided in the summer of 2002.

Nationwide only two proposals in the field of Physics went on to the second round of evaluation. One of thes was teh "Center for soft condensed matter research" where Prof. Alex Hansen is the administrative and scientific leader. This proposal represents a collaboration between NTNU, The University of Oslo and The Institutte for Energy Technology (IFE) at Kjeller.

In addition, two other Center of Excellence proposals involve scientists from the department of Physics, namely "NOBIPOL - Center for Bioploymer Engineering at NTNU" (inthe field of biotechnology) and "Light Metals Technology" in the field of materials technology).

STAFF

Scientific

Professors (34)
Johannes Bremer, Anne Borg, Catharina Davies, Arnljot Elgsæter, Johannes Falnes, Kristian Fossheim, Alex Hansen, Eivind Hiis Hauge, Randi Holmestad, Per C. Hemmer, Ola Hunderi, Ragnvald K. O. Høier, Johan S. Høye, Anders Johnsson, Hans Kolbenstvedt, Tore Lindmo, Ole J. Løkberg, Thor Bernt Melø, Frode Mo, Kjell Mork, Jan Myrheim, Kalbe Razi Naqvi, Kåre Olaussen, Hans M. Pedersen, Steinar Raaen, Emil J. Samuelsen, R. Svein Sigmond, Bo-Sture Skagerstam, Helge R. Skullerud, Kim Sneppen, Bjørn Torger Stokke, Asle Sudbø, Arne Valberg, Erlend Østgaard.

Adjunct professors (7)
Lasse Amundsen, Petr Hadrava, Kjell A.Ingebrigtsen, Anna Midelfart, Einar Rofstad, Arne Skretting, Tor Wøhni.

Associate professors (13)
Jon Otto Fossum, Per Morten Kind, Berit Kjeldstad, Magne Kringlebotn, Jørgen Løvseth, Tore H. Løvaas, Arne Mikkelsen, Kåre Stegavik, Knut Arne Strand, Thorarinn Stefansson, Bård Tøtdal, Sigmund Waldenstrøm, Ingjald Øverbø.

Researchers (7)

Ali Ata, Geraldo da Silva, Paul Gunnar Dommernes, Jon Kåre Hansen, Morten Kildemo, Ragnvald Mathiesen, Yingda Yu,

Senior staff (4)
Knut Lønvik, Reidar Nydal, Haakon Olsen, Ivar Svare.

Doctor students (52)

Doctor of Engineering (36)
Carmen Andrei, Audun Bakk, Torkel Bjarte-Larsson, Alv Borge, Øyvind Borck, Dag Werner Breiby, Signe Danilesen, Live Eikenes, Jesper Friis, Anders Frøseth, Fredrik Hansteen, Hans Kristian Helgesen, Joakim Hove, Henning Knudsen, Calin Daniel Marioara, Gjertrud Maurstad, Sjur Mo, Lars Henrik Morset, Jørgen Nyhus, Stine Nalum Næss, Trond Ramsvik, Per Kristian Rekdal, Øystein Risa, Terje Røsten, Jo Smiseth, Eivind Smørgrav, Trude Elna Støren, Oddbjørn Sæther, Torbjørn Sund, Ulrik Thisted, Heidi Kristine Toft, Khanh Minh Vu, Per Erik Vullum, Hans Magne Ådland.

Doctor of Science (16)
Tom Kristian Bardal, Bjørn Bergsjordet, Berit Bungum, Nils Erland L.Haugen, Egil Holvik, Qu Hong, Terje Meisler, Devi Dhavraj Meena, Gunnar Prytz, Ståle Ramstad, Ellen Roll, Inger Rudvin, Marit Sletmoen, Hege Widerøe, Roland Wittje, Dag Østvang

Technical/administrative

Senior engineer (1)
Brian Wall

Chief engineers (2)
Per M.Lillebekken, Oddbjørn Grandum.

Engineers (20)
Irene Aspli, Lars Berntzen, Arnolf Bjølstad, Rolf Dahl, Inger B.Følstad, Knut R.Gjervan, Ole K.Holthe, Tor Jakobsen, Dagfinn Johnsen, Erling Kristiansen, Jan S. Mastad, Arne Moholdt, Anniken Paulsen, Jon Ramlo, Inge Sandaunet, Bertil O. Staven, Tor A. Vassdal, Arild Vatn, Geir Wiker, Lise Wohlen.

Master craftsmen (2)
Kjell O. Ramsøskar, Kåre O. Rokhaug.

Office (6)
Ann-Lisbeth Geelmuyden, Margit C.Hagen, Inger Kosberg, Inger J. Lian, Eli Monsøy, Tove G. Stavø.

THESES

Doctoral study

Borge, Alv; *A study of self-consistent equations of state*
Supervisor: Professor Johan Høye

Nyhus, Jørgen; *Resonant Ultrasonic System Design, and Measurements of Critical Behaviour and Flux-Line Elasticity in High Temperature Superconductors.*
Supervisor: Professor Kristian Fossheim

Calin, Marioara Daniel; *A TEM Study of the Precipitates in a 6082 Al-Mg-Si Alloy System*
Supervisor: Professor Ragnvald Høier

Ramsvik, Trond; *Surface science studies of Cobalt and Rhodium single crystal surfaces*
Supervisor: Professor Anne Borg

Rekdal, Per; *Some Non-Perturbative Results in Modern Quantum Optics*
Supervisor: Professor Bo-Sture Skagerstam

Prytz, Gunnar; *A Biophysical Study of Oscillatory Water Regulation in Plants. Measurements and Models*
Supervisor: Professor Anders Johnsson

Widerøe, Hege Christin; *31 P NMR – and high-resolution 1H MAS NMR studies of intact cancer and bacterial cells. An experimental investigation of the effects induced by the Ca2+ ionophore A23187, daunorubicin and ALA-PDT*
Supervisor: Professor Anders Johnsson

Østvang, Dag; *A Non-Metric Approach to Space, Time and Gravitation*
Supevisor: Professor Kåre Olaussen
.

Graduate study

Agersborg, Stein Petter; *Absolute Shape measurements using Structuresd light with Noncollimated Illumination and Observation.* Supervisor: Professor Ole Johan Løkberg.

Alnes, Håvard; *Nodal Quasiparticles and Vortex-loop in extreme type-II suoerconductors.* Supervisor: Professor Asle Sudbø.

Andresen, Nils Ulrik; *Self-consistent Ornstein-Zernike approximation for the two-dimensional lattice gas with interactions of medium range.* Supervisor: Professor Johan Skule Høye.

Andresen, Yngve Tofte; *Low Frequency Noise in High-Tc Superconducting Quantum Interference Devices and Multilayer Magnetometers.* Supervisor: Professor Kristian Fossheim.

Anmarkrud, Vidar; *Reproduction of spatial room acoustical attributes using cross-talk cancellation techniques.* Supervisor: Professor Olle Johan Løkberg.

Arentz, Cecilie; *Characterization of cervical cancer using micro MRI, high resolution MAS MR spectroscopy and multivariate analysis.* Supervisor: Professor Catharina Davies.

Bäcklund, Are; *Subgrain structure and dispersible distribution in AlMgZn alloys.* Supervisor: Professor Randi Holmestad.

Badiee, Azadeh; *Reproducibility of gene expression analysis performed by RNA-blot and cDNA microarray.* Supervisor: Professor Tore Lindmo.

Bay, Tonje Holter; *Heterogeneity in blood flow in tumour tissue mesasured by magnetic resonance imaging.* Supervisor: Professor Einar K.Rofstad.

Berg, Kristin Nergaard; *Tissue velocity estimation and tracking based on RF utrasound data.* Supervisor: Professor Catharina Davies.

Bjørnstad, Petter; *Hardness and microstructure development in AlMgSi alloys.* Supervisor: Professor Randi Holmestad.

Borck, Øyvind; *Operator Regularization.* Supervisor: Professor Kjell Mork

Brecke, Kjell Morten; *Theoretical and experimental studies of Doppler frequency spectra in Optical Doppler Tomography.* Supervisor: Professor Tore Lindmo

Dalen, Ingvild; *Statistical Models and Calculations related to Mixture Evidence in Forensic DNA testing.* Supervisor: Professor Tore Lindmo.

Dalen, Lene; *Students' Perceptions of Technology.* Supervisor: Associate Professor Per Morten Kind.

Davis, Kaia Margit; *Identification and validation of genes differentially regulated by dehydration in the rat hypothalamus using microarrays.* Supervisor: Professor Bjørn Torger Stokke.

Engstrøm, Vegard; *Categorization of educational software in physics.* Supervisor: Associate Professor Per Morten Kind.

Fløan, Inge; *Magneto-optical investigation of the flux landscape in* $Yba_2Cu_3O_{7-\delta}$ *thin film structures.* Supervisor: Professor Kristian Fossheim.

Foss, Sean Erik; *Electron Spin Configuration of Manganites at Low Doping.* Supervisor: Professor Asle Sudbø.

Gaudestad Jan Olaf; *HTS SQUID Determination of Corrosion on Aluminium.* Supervisor: Professor Kristian Fossheim.

Gjellestad, Axel; *A method to determine the complex refractive index of an inhomogeneous object.* Supervisor: Professor Ola Hunderi.

Grøver, Arnt; *Methods for ultrasound contrast agent detection: Powermodulation compared to pulse inversion.* Supervisor: Professor Jan Myrheim.

Hagen, Espen; *The Stock Market - A dynamic System.* Supervisor: Professor Jan Myrheim.

Hakvåg, Magnus; *Analysis of a potential method for measuring physiological core temeperature.* Supervisor: Professor Tore Lindmo.

Halnes, Geir; *Effective potential for light in movong media.* Supervisor: Professor Kåre Olaussen.

Hansegård, Jøger; *Bystander effects in photosensitized cell inactivation. The effect of reactive oxygen species.* Supervisor: Professor tore Lindmo.

Harholt, Henning; *A TEM study of solar cell silicon.* Supervisor: Professor Ragnvald Høier.

Haugen, Kjartan Nesbakken; *Physical properties in high temperature single crystal LASCO and YBCO Superconductors.* Supervisor: Professor Kristian Fossheim.

Hopsnes, Øyvind; *Specification, design and (partial) implementation of an automatized system for converting document formats.* Supervisor: Professor Kåre Olaussen.

Haakestad, Magnus Willum; *Initial Small-Angle Neutron Scattering Studies of a Synthetic Clay: sodium Fluorohectorite.* Supervisor: Associate professor Jon Otto Fossum.

Jensen, Kirsten Margrete; *Studies of Taxoteres Effects on Radiosensitivity and growth rate of the Breast Cancer Cell Line MCF-7 In Vitro and In Vivo.* Supervisor: Professor Catharina Davies.

Jørgensen, Tor Erik; *Polymer organisation during gelation of the algal polysaccharide alginate. Experimental characterisation of gelation kinetics and structure.* Supervisor: Professor Bjørn Torger Stokke.

Kjølaas, Jørn; *The effect of cement on deformation: Experiments on Synthetic rock and Modelling.* Supervisor: Professor Alex Hansen.

Koen, Kristian; *Optical Coherence Tomography on Semitransparent Tissue with Multiplexed Light.* Supervisor: Professor Ola Johan Løkberg.

Konst, Bente; *Fricke based Gel Dosimeters: Influence of gel parameters on iron ion diffusion and radiation sensitivity.* Supervisor: Professor Bjørn Torger Stokke.

Kristiansen Øyvind; *On the modelling of floods in rivers with example from Glomma.* Supervisor. Professor Johannes Falnes.

Marthinsen, Torunn Hiorth; *Isotropic and nematic phases in mixtures of rod-like colloids and polymers.* Supervisor: Professor Per Christian Hemmer.

Mortensen, Tore; *Pykonuclear reactions, fusion at extreme high dansities.*Supervisor: Professor Erlend Østgård

Nilsen, Anne-Cathrine; *The use of practical work in physics education.* Supervisor: Associate Professor Per Morten Kind.

Nilsen, Kristian; *Balanced state in Networks of Cortical Neurons*. Supervisor: Professor Alex Hansen.

Normann, Sverre; *Direct and Diffuse Ultraviolet Radiation- Instrumenation, Calibartiona and testing*. Supervisor: Associate professor Berit Kjeldstad

Ormberg, Ida Wendelbo; *Coregistration of MR- and CT-images for use in brachytherapy*. Supervisor: Professor Arne Skretting.

Røkenes, Kjersti; *Development of methods for analysis of wind measurements*. Supervisor: Associate Professor Jørgen Løvseth.

Røste, Thomas; *The maximum mass and radius of Neutron Stars*. Supervisor: Professor Erlend Østgård

Sande, Silje Østensen; *Centirfugal Forces near Black Holes*. Supervisor: Professor Erlend Østgård.

Sivertsen, Heidi; *Spectral measurements of ultraviolet radiation*. Supervisor: Associate Professor Berit Kjeldstad.

Sivertsen, Tom Arne; *Electromagnetic Forces on Microparticles in Evanescent Fields*. Supervisor: Professor Kåre Olaussen.

Skoe, Rune Hovland; *A model of the Propagating Interface between Two Immiscible Fluids in 2D*. Supervisor: Professor Alex Hansen.

Skotheim, Øystein; *HoloVision - A software package for reconstruction and analysis of digitally sampled holograms*. Supervisor:Professor Ole Johan Løkberg.

Skrøvseth, Stein Olav; *Entanglement in a system of Harmonic Oscillators*. Supervisor: Professor Kåre Olaussen.

Smevik, Torunn; *Analysis and simulation of a French Horn*. Supervisor: Professor Ole Johan Løkberg.

Smiseth, Jo; *Momentum distribution and critical exponents of 1d Hubbard model with the projector quantum Monte Carlo method*. Supervisor: Professor Asle Sudbø.

Smørgrav, Eivind; *Quantum Critical points: Metal-insulator transition in the 2D large U Hubbard model as a 3D thermally driven metal-superfluid transition*. Supervisor: Professor Asle Sudbø.

Sviggum, Stian; *Electrochemical AFM. In situ studies of corrosion and chromatization on aluminium*. Supervisor: Professor Anne Borg.

Sælevik, Gunnstein; *Microfluidic analysis using Particle Image Velocimetry*. Supervisor: Professor Johan Skule Høye.

Tuft, Vegard Larsen; *Fringe resolution in digital holographic interferometry*. Supervisor: Professor Ola Johan Løkberg

Vangberg, Lars; *Uptake of NC100150 in human melanoma xenografts*. Supervisor: Adjunct Professor Einar Kåre Rofstad.

Vines, Lasse; *Differential Fiberoptic Gyroscope: A theoretical and Experimental Study*. Supervisor: Professor Hans Magne Pedersen.

Vullum, Per Erik; *TEM-studies of the perovskite system* $La_4Sr_2Fe_6O_{18-\delta}$. Supervisor: Professor Randi Holmestad.

Wallem, Tore; *Intracapillary oxyhemoglobin stauration in cervix cancer measured by cryomicrospectrophotometry*. Supervisor: Adjunct Professor Einar Kåre Rofstad.

Wangensteen, Magnus; *Current conductionin thin polymer foils at high electric fields*. Supervisor: Professor R.Svein Sigmond.

Wingstedt, Emil; *Signal validation and fault detection in steam-turbine cycles*. Supervisor: Professor Johan skule Høye.

Yousef, Hanna Ali; *Calculating Trajectories of Discontinuous Elements in a Two-Dimansional Wind Field*. Supervisor: Associate Professor Berit Kjeldstad.

Aalerud, Tommy Nakken; *Synchrotron X-ray Scattering Studies of Water Intercalation in Synthetic Nickel-Fluorohectorite*. Supervisor: Associate Professor Jon Otto Fossum.

PUBLICATIONS

Andresen, Nils U.; Borge, Alf; Høye, Johan S.
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Bakk, Audun; Høye, Johan S.
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Bremer, Johannes; Vaicikauskas, Victoras; Hansteen, Fredrik; Hunderi, Ola
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Bremer, Johannes; Seime, Lars; Hunderi, Ola; Hansteen, Fredrik
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Davies, Catharina de Lange; Melder, Robert J; Munn, Lance L; Mouta-Carreira, C; Jain, Rakesh K; Boucher, Yves
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Falch, Berit H.; Stokke, Bjørn T.
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Gjervan, Torbjørn; Prestvik, Rune; Tøtdal, Bård; Lyman, Charles E.; Holmen, Anders
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Hansen, Alex; Schmittbuhl, Jean; Batrouni, G. George
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Hartmann, Martin; Holm, Olav B.; Johansen, Gunn A.B.; Skjåk-Bræk, Gudmund; Stokke, Bjørn T.
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Physica A 294: 323 - 339. 2001.

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Olivi-Tran, Natalie; Batrouni, George; Hansen, Alex
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CURRICULUM

Siv.ing. study, 1th and 2nd year.	***Student attendance*:**	**2120**
Physics for Civil and Environmental Engineering		172
Physics for Geology and Petroleum Students		69
Physics for Electronics Students		206
Physics for Chemistry and Metallurgy Students		162
Physics for Computer Students		404
Physics for Machine Technology Students		234
Physics for Marine Students		90
Laboratory for Physics Students 1		148
Laboratory for Physics Students 2		134
Laboratory for Physics Students 3		123
Laboratory for Physics Students 4		118
Mathematical Physics		147
Physics for Energy and Environmental students		113

Siv.ing. study, 3rd year.	**634**
Physics 2 for Electronics Students	104
Experimental Physics 1	61
Experimental Physics 2	56
Statistical Physics	56
Electromagnetic Theory	44
Atomic and Molecular Physics	71
Optics	66
Quantum Mechanics	51
Electron and Ion Physics	9
Astrophysics	26
Cell Biology 1	51
Atmospheric Physics	3
Material Physics and Characterization	36

Siv.ing. study, 4th year.	**291**
Global Transport in Nature	2
Nuclear and Radiation Physics	56
Solid State Physics	41
Energy and Environmental Physics	16
Non-linear Dynamics	15
Physics of Stars	5
Optics, Advanced Course	10
Applied Quantum Mechanics	6
Numerical Physics	4
Solid State Physics, Advanced Course	14
Material Science	6
Theory of Classical Fields	6
Molecular Biophysics	16
Biophysics (special)	15
Classical Transport Theory	6
Signal Processong	6
Subatomic Physics	1
Medical Physics	16
Nuclear and Radiation Physics	56
Experts in Team, Interdiscipinary Project	

Siv.ing. study, 5th year.	**41**
Biophysical Micromethods	1
Biophysics, Specialization	12
Physics, Specialization	28

Dr.ing. study.	**32**
Quantum Optics	2
Characterization of Solid Surfaces - Surface Physics	3
Photon Physics	1
Ocean-Wave Energy	3
Phase Transitions and Critical Phenomena	6
Light and Neutron Spectroscopy	2
Application of Symmetry Groups in Physics	9
Biological Physics	1
Interactions of Ionizing Radiation with Matter	5

Cand.mag. study.	**209**
User Course in Physics	39
General Physics I	48
General Physics II	39
Mechanics	2
Electricity and Magnetism	19
Quantum Physics and Statistical Physics	22
Electronics	4
Energy and Environmental Physics	6
Biophysics I	4
Introduction to Quantum Physics	8
Astro Physics	18

Cand.scient. study.	**74**
Physic Fagdidatic	12
Measuring Sensors and Transducers	11
Signal Analysis	7
Matematics and Geophysics	2
Physics of the Atmosphere	10
Physics of Stars	4
Cosmology and Extraterrestrial Biology	5
Subatomær Physics	5
Cosmology and Astro-particle Physics	9
Particle Physics	5
Relativistic Quantum Mechanics	4

Dr.scient. study.	**25**
Compact Stars	13
Quantum Field Theory	5
Quantum Flavour and Quantum Chromodynamics	3
Quantum Optics	4

Other subjects.	**25**
Electronics	2
White Dwarfs	1
Light, Sight, Colour	2
Space Technology	20