Physics Research at Norwegian Universities, Colleges and Research Institutes

A Review

Volume I

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Preface

This is the report of an international committee formed by the Research Council of Norway to review and assess the research in physcis at Norwegian Universities, Colleges and Research Institutes. This report has been prepared specifically for the Research Council of Norway, which reserves the right to use the contents as it sees fit.

The committee was given reports from the departments and research groups about six weeks prior to their 30 January – 4 February, 2000, meeting in Oslo where the committee met for interviews with representatives from the groups to be reviewed. A subsequent meeting of the committee members only to sum up their conclusions was held on 30 – 31 March, also in Oslo.

The committee was able to discuss research-related issues with a significant number of responsible staff and thus obtained sufficient information on which to base a well-balanced and fair assessment. The committee is confident that its analysis and recommendations are generally well founded. We hope that this report will not be regarded as a final ”judgement”, but rather will be looked upon as a constructive basis for future improvement, change, and development of physics in Norway.

To the Research Council of Norway

The members of the evaluation committee on physics at Norwegian Universities, Colleges and Research Institutes hereby submit the following report.

Our task has been to make an adequate, comprehensive, and fair review of the research activities in physics in Norway during the last five years, and to make remarks about possible future developments. This task has been demanding in view of the short time available, and the fact that most committee members were unfamiliar with the Norwegian academic scene before beginning this assignment. The committee hopes that the review will nevertheless be a worthwhile source that can be used by the Research Council of Norway, as well as by the faculties, institutions, departments, sections, and research groups concerned.

The views expressed in this report are the consensus views of the committee. The members of the committee are in collective agreement with the assessments, recommendations and conclusions presented.

Örjan Skeppstedt
Chairman

Wolfgang Baumjohann | Rienk van Grondelle

Günter Kaindl | Christopher Pethick

Gigi Rolandi | Robert Rosner

Content

1 Summary of recommendations

Powerful activities in Norwegian physics can generally be found in fields in which there is strong Norwegian involvement in international collaborations. Such fields are astronomy, high-energy physics and space physics. There is little research in Norway in some fields of physics which internationally are very active. Examples are semiconductor physics, solid-state magnetism, low-temperature physics, non-linear optics, femtosecond spectroscopy and biological physics.

The evaluation committee has found several examples of non-focused activities and diversified group structures in the departments and research institutes being evaluated. There is a problem with a non-existing career structure with few openings of fellowships for postdoctoral studies abroad and postdoctoral positions in Norway. The age structure of the groups is in many cases such that several retirements will occur in the near future. The immediate conclusions to be drawn from these observations are that initiatives should be taken to create a visible academic career system, initiating new research in selected fields, phasing out some stagnating activities and strengthening and focusing the group structure in the university departments and research institutes. A good opportunity to restructure Norwegian physics research exists as a consequence of the large number of retirements in the coming years. The evaluation committee therefore recommends a fast procedure for creating mechanisms for defining long-term strategies and setting priorities.

In summary, the evaluation committee recommends the following concrete actions:

- A new academic career system should be created. Young students should be offered a visible system for foreign doctoral and postdoctoral studies and possibilities for time-limited postdoctoral positions at the Norwegian universities and research institutes. A tenure track system should be considered.

- The small scientific community in Norway with few universities implies difficulties with mobility and the risk of scientific inbreeding. The community should be observant on this problem and stimulate mobility as much as possible. Inbreeding should be counteracted by increased international interactions. Young scientists should be strongly stimulated to spend a few years abroad for postdoctoral studies. International recruitment of new faculty for key positions should be done. Programs for inviting guest scientists should be created.

- In some Norwegian university departments the in-house activity in basic experimental physics is extremely low. This constitutes a danger for the scientific environment in these departments. The committee recommends to stimulate the development of new in-house experimental activities in physics and in closely related areas. The in-house experimental activities should be enlarged by e.g. international invitations of guest scientists and postdoctoral fellows in fields other than those connected with large-scale facility research.

- The Research Council and the governing bodies of the university departments and the institutes should stimulate the communities to define long-term strategies and set priorities. This could be done by requirements of creating and continually updating strategy documents. The strategies should include academic careers, positions, focusing and restructuring activities in the research groups, development of existing fields, phasing out fields and creating new fields. The work with strategies should be implemented rapidly in order to plan for redirection of resources made available when retirements occur. An increased co-operation between the Research Council and the university departments and research institutes concerning long-term strategies is recommended.

- The Research Council should look over the time-limited basic research programs. Such programs have a strong potential for starting up new research areas and/or for strengthening important scientific fields. There should, however, be a very careful planning of the specific program. The success of a program should be evaluated at pre-determined occasions and plans for a continuation or phasing out of activities should be worked out in due time before the end of the support from the Research Council within the framework of the basic research program.

- In addition to the above-mentioned basic research programs, other models for programs for stimulating collaboration between individual scientists and groups of scientists at the same location as well as at different departments and institutes should be considered. Such programs should be time-limited with possibilities for extension after external and international evaluations.

- The evaluation committee strongly recommends a general increase of the funding level for expensive equipment. The funding should preferably be directed towards instrumentation that creates powerful in-house scientific environments in the universities. New instrumentation should be part of long-term strategies for the universities and institutes.

- The evaluation committee emphasises the following specific recommendations.

  – New initiatives in non-linear optics and laser spectroscopy are recommended at the Norwegian University of Science and Technology in Trondheim and at the University of Oslo. They should open up new research lines in condensed matter physics and materials science and allow interdisciplinary activities involving bioscience and chemistry.

  – The field of experimental condensed-matter physics/materials science should generally be strengthened. The departments of physics at the four major universities in Norway should offer teaching and graduate research in the field.

  – Space physics should be phased out at the University of Bergen. Space-borne instrument building should be moved to the University of Oslo. This implies an increased size of the space research group in Oslo since a strong effort in space-borne instrumentation is essential for keeping Norway at the forefront of space physics.

  – Experimental low-energy nuclear physics should be phased out and the experimental activity in nuclear physics at the University of Oslo should be focused on the ultrarelativistic heavy ion collision experiments. The activities in experimental high-energy subatomic physics in Oslo should be concentrated to one group, which should have a close collaboration with the University of Bergen for continuation and strengthening of the Norwegian international participation in high energy physics, with an emphasis on utilising the CERN membership.

  – A new program on environmental and energy research at the University of Oslo should be started.

- Extragalactic astronomy should be strengthened at the Institute of Theoretical Astrophysics in Oslo aiming at an effective involvement in the Planck program. The present size of the faculty at this institute should be kept to maintain the high-quality research done in the institute.

- A program for atmospheric physics at the University of Tromsø should be created. The evaluation committee suggests a formulation of a strategic plan for such a group, in which explicitly a new in-house activity in the area of molecular physics related to physical processes in the atmosphere is considered. The evaluation committee advises to discontinue the research in experimental plasma physics in Tromsø.

- The Norwegian theoretical physics community is in many respects doing well, although there is a considerable fragmentation among the groups and a number of one-person activities are going on. An overall recommendation is to focus activities and to strengthen the environments for theory activities. Attention should be paid to increasing international collaborations. This can be stimulated by increased funding of postdoctoral fellows and senior visitors.

* Even though the evaluation committee proposes new programs and the phasing-out of some existing activities, it strongly recommends that the Norwegian scientists be involved in the work of changing structures and activities. The evaluation committee essentially proposes bottom-up procedures with the best Norwegian scientists involved with advice from international experts.

The proposed actions should be implemented over a period of some years utilising resources freed up by sizeable retirements in the nearest future within the university departments of physics and research institutes in Norway. An increased funding of Norwegian physics should speed up the procedure and is recommended by the evaluation committee. However, a careful planning of redirection of existing resources over time, should enable a fruitful restructuring of the present activities and building up a modern structure of the physics research in Norway.

2 Introduction

2.1 Mandate

Following the decision by the Research Council of Norway to review Norwegian research in physics, the Council invited seven qualified scientists representing various fields within the discipline to undertake this task. A committee was established and charged with the mandate presented in Appendix 2.

The review should include both theoretical and experimental aspects of the following subfields of physics: Particle physics, nuclear physics, atomic and molecular physics, solid state physics, biophysics, plasma physics, optics, physics of the middle and upper atmosphere as well as astrophysics, and lead to a set of concrete recommendations to the Research Council concerning future developments in the field of physics research in Norway. In addition, the following main aspects were to be considered:

- scientific activity and quality;
- international and national collaboration;
- training and mobility;
- relevance of the scientific research.

2.2 Panel Members

The evaluation committee consisted of the following experts (their CVs are presented in Appendix 1):

Professor Örjan Skeppstedt Manne Siegbahn Laboratory Frescativ. 24 S-104 05 STOCKHOLM Sweden	Professor Wolfgang Baumjohann Institut für Extraterrestrische Physik P.O.Box 1603 D-85740 GARCHING Germany
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Senior adviser Synnøve Irgens-Jensen of the Research Council of Norway presented the instructions to the research groups, arranged for the meetings with the committee and the groups, and collected statistics of research activity and results from each groups.

Katarina Wilhelmsen-Rolander, assistant professor at the Department of Physics, Stockholm University of Technology, acted as scientific secretary of the evaluation committee. She compiled and organised the submitted reports from the research groups, as well as the final report of the committee. Executive Secretary Signe Dahle Urbye of the Research Council of Norway assisted the committee in processing the report.

2.3 Key information and major issues of the review process

In the spring of 1999, the Research Council of Norway informed the relevant institutions of its plan to review and evaluate, on an international level, the research in the field of physics at Norwegian universities and at such other institutions where a significant amount of basic research in the field is carried out. Professor Örjan Skeppstedt, director of the Manne Siegbahn Laboratory at the University of Stockholm, was appointed chairman of the committee. The evaluation committee was constituted in November of the same year, after proposals for committee members had been received from the groups to be evaluated.

The institutions were informed of the committee mandate and were presented with a request to supply the Research Council with background information (letter to the institutions in Appendix 3). The reports from the institutions were then sent to the committee members for review. Subsequently they were edited and compiled in volume II of the evaluation report, together with two reports from Norwegian Institute for Studies of Research and Higher Education (NIFU).

The committee met twice in Gardermoen near Oslo: 30 January - 4 February and 30 - 31 March, 2000. During the first meeting the groups that were to be evaluated were invited to send representatives to present their work for the entire committee, and to discuss with them their situations and future plans.

The reported opinion of the evaluation committee is based on the information supplied by the groups to the committee as well as publication and citation records obtained from the ISI database.

2.4 Outline of the review report

In chapter 3 a national portrait is presented. In this chapter Norwegian physics research is put into an international perspective. The structure of departments, age distribution, career paths and strategies are reviewed and presented.

In chapter 4 the evaluation committee presents the results of the review process and assessments and recommendations are given both for individual groups and for the departments. The summary of chapter 5 gives general conclusions for different areas of physics and a summary of the recommendations of the committee.

3 National portrait

3.1 General introduction

Research in physics addresses fundamental aspects of nature spanning distances and time scales from micro-cosmos to macro-cosmos and from billionths of femtoseconds to billions of years. The goals of physics research are to study the different phenomena that are present across these gigantic scales, to design the experimental tools for new observations and to create models and theories to explain the observed phenomena. Progress in physics has strong implications for related sciences, engineering, and technology, and in this way, on practically all aspects of everyday life. Physics has become crucial for continually creating new ideas, new instruments and techniques as well as new applications.

A small country like Norway can hardly develop strong communities in all areas of the broad field of physics. This implies that individual scientists, universities and funding agencies must make choices. In Norway, as in so many other countries, the strongest activity is associated with productive research environments where there are a number of scientists with overlapping interests. Largely for historical reasons these environments have grown up in particular fields, and there are some fields of physics, for example semiconductor research, solid-state magnetism, low-temperature physics, non-linear optics, femtosecond spectroscopy, and biological physics, in which very little research is being done in Norway. The fact that in Norway there are relatively large numbers of scientists participating in international collaborations associated with large facilities has also influenced the balance between the different fields in the country.

3.2 The main research areas

In the following subsections, the main research areas of physics are briefly described with some general comments about the activities in Norway.

3.2.1 Atomic, Molecular and Optical Physics

Historically, the foundations of modern quantum theory were laid in the context of atomic physics, and physicists in the Scandinavian countries played an important role. Norway has strong traditions in the area, and Hylleraas and Rosseland were among the pioneers. Over the past three decades the subject has undergone a revolution due to the development and extensive exploitation of lasers. This has opened up numerous new fields of investigation, and has made it possible to measure atomic and molecular properties with great precision, and to investigate a wealth of phenomena, not only in physics but also in chemistry and in biology.

To reflect the close connections between atomic physics and related areas it is customary today to speak of atomic, molecular, and optical physics as one subject, rather than as distinct sub-fields. Among the important areas opened up by the use of lasers over the past decade is the study of cold atoms, which led to the realisation of Bose-Einstein condensation in dilute gases. The international physics community has watched an amazing progress in laser technology to produce ultrashort laser pulses of high power and with well-defined spectral and temporal properties. Amplification schemes for such pulses were developed leading to the design and application of a large variety of non-linear optical devices.

Ultrashort pulsed lasers have been applied in a large variety of non-linear optical techniques with a multitude of applications in condensed matter physics and materials science. The 1999 Nobel prize in chemistry to Ahmed Zewail symbolises the progress made in "femtochemistry", where femtosecond lasers are used to prepare and investigate the transition states in chemical reactions. Non-linear femtosecond spectroscopic techniques are used to investigate the dynamics of solvents. Similarly, ultrashort laser pulses are applied to discover the elementary events in vision and photosynthesis. One of the challenges in the future will be the use of high-power femtosecond lasers for generating coherent femtosecond X-ray pulses. These can be applied in a kind of "real-time holography" to study, with high spatial and time resolution, structural changes e.g. in chemical reactions, and, more important, transitions in biological molecules.

Lasers play an important role not only in basic science but also in many applications. Important examples are the use of lasers in manipulation (optical tweezers) and in the etching of patterns. Possibly one of the most promising developments is to use femtosecond lasers in all kinds of imaging processes based on the non-linear interaction between the laser pulse and the material (two-photon fluorescence, third-harmonic imaging etc.). A variety of cellular events have been imaged with high spatial resolution and speed.

The studies of properties of atomic clusters, kept together by electrostatic, covalent or van der Waals forces, is an expanding area in modern natural science and technology research. The area is interdisciplinary, with a coupling between physics, chemistry and technology, and with a potential for production of materials with special properties. The studies include efforts to find the optimal sizes of clusters for applications in catalysis, sensors, optical and magnetic materials or for building-blocks of nano-structure materials and mesoscopic structures.

Storage and cooler rings for ions have made new types of precision experiments in atomic and molecular physics possible. In the field of molecular physics, processes occurring in the atmospheres of the earth and other planets and in interstellar space have been studied under controlled conditions in the laboratory.

Atomic spectroscopy methods for sensitive determinations of trace elements are used in many applications within environmental research, e.g. probing air or water pollution.

Another related area which has developed rapidly in recent decades is quantum optics. At the present time, research in quantum information, and the possibility of using quantum processes for computing is growing rapidly.

In Norway there are only five-six theorists working in the area, and there is no experimental activity apart from the work on ionised gases at the Norwegian University of Science and Technology (NTNU) in Trondheim. Research on modern aspects of the subject is largely absent.

3.2.2 Applied physics

Even though physics is a fundamental science, that increases our understanding of nature, it generates knowledge with far-reaching consequences for various applications. The interfaces between physics and other branches of science like chemistry, biology and geoscience as well as engineering and technology are fields where applications of physical concepts and methods are of increasing importance. Condensed-matter physics and materials science are so tightly interwoven that the boundaries are hardly discernible. The term “applied physics” is, however, most often associated with applications of physics in technology, medicine as well as in energy and environment, and this terminology is adopted here. In many of the applications the borders between physics and engineering are frequently crossed, and it is in particular the interaction between physics and engineering that is often the basis for the development of new technologies with crucial implications for society.

In Norway activities that can be described as “applied physics” are most visible in the Department of Physics at the University of Bergen (UiB), but can also be found in other departments and institutes. In the 80’s and 90’s the Department of Physics in Bergen has redirected resources from exclusively basic research towards activities in applied research and technological development. Today, about half of the scientific staff at this department belongs to a section of Applied Physics and Technology with activities in hydroacoustics, reservoir physics, optical and laser physics as well as in process safety and technology. A considerable part of the work is in the fields of microelectronics and industrial instrumentation and is done in close collaboration with either the CERN-related high-energy physics groups or the space-physics groups in Bergen. At NTNU in Trondheim, a small group is working with applied optics within the Section of Condensed-Matter Physics and Optics. There is also a small group at NTNU in the Section of Biophysics, working with technological applications in medicine. At the Department of Physics at the University of Tromsø (UiT) an initiative to create an activity in applied physics (communications and microelectronics) was taken in the beginning of the 90s with the aim to attract more students. In the Department of Physics at the University of Oslo (UiO), groups working in applied physics can be found in the sections of Biophysics (medically/cancer research), Electronics (industry related, e.g. sensors) and Nuclear and Energy Physics (solar energy and radiation applications).

3.2.3 Astrophysics

Astronomy is a field of physics that attracts large interest in the general public, and an early interest in astronomy is often at the root of a career in science. The major progress and discoveries in astronomy are mainly the result of dedicated efforts concerning ground- and space-based telescopes and detectors. Development of new technology results in larger and more sensitive instruments, possibly operating at previously unexplored wavelengths, that can detect weaker and weaker objects over increasingly broader wavelength regimes, allowing astronomers to see objects further away in space and time, or with lower intrinsic emission levels. The number of examples is astonishing in its variety and in the profundity of its results: The Hubble Space Telescope has recorded a large number of galaxies in their early stages of evolution; sensitive receivers in the millimeter, submillimeter, and microwave range have discovered a population of gas and dust-rich objects in the early universe, and are probing the structure of the universe when it was less than a million years old; X-ray satellites, from Einstein and ROSAT to the new Chandra and Newton XMM observatories, are exploring the presence of dark matter, matter dominates the gravitating mass of the universe but is completely different from the matter that we are composed of; radio, optical, and infrared observations are probing the birth of stars and planets in our galaxy; optical imaging spectroscopy (such as carried out by the Global Oscillation Network Group [GONG] and the MDI instrument on the SOHO satellite), together with neutrino observatories, are used to probe the internal structure of our Sun; and the Compton Gamma Ray and Beppo-Sax satellites, together with the Keck, VLT, and other optical telescopes, which have allowed observations that are revealing the origins of gamma-ray bursts in the early universe (these bursts may signal the formation of a black hole in a supernova, or the collision of two neutron stars). New-generation large-area CCD detectors, coupled to highly automated wide-field telescopes, are being used to conduct automated digital sky surveys and, because of the extremely large number of objects observed, are finding large numbers of previously rare objects such as high redshift quasars; these surveys are also used to find and observe large numbers of supernovae in distant galaxies, research which strongly suggests that - contrary to previous observations and theory - the expansion rate of the universe is increasing. Finally, huge ground-based air shower arrays are being used to locate the mysterious sources of the remarkable extremely relativistic (> 10^{20} eV) cosmic rays.

In Norway, 10 of the 13 astrophysicists are located in one institution, the Institute of Theoretical Astrophysics (ITA) in Oslo. As a consequence, a critical mass research effort in astrophysics is only carried out at the ITA, where the research concentrates largely on solar physics and cosmology/extragalactic astronomy. Most of the research areas of astrophysics are therefore not represented in Norway, which is not surprising given the small number of astronomers in Norway. While Norwegian astrophysicists are involved in a number of international collaborations, inter-institutional collaborations within the country are scarce.

3.2.4 Biological physics

Biological physics has arisen as a large international research field at the interface of physics, chemistry, biology, and medicine. Key areas include fundamental aspects of the structure and dynamics of biomolecules (proteins, nucleic acids, membranes), energy conversion in biological systems (photosynthesis, respiration), physical aspects of e.g. signal transduction at the biomolecular or cellular level etc. Studies of biosystems include signal processing by the brain (e.g. in vision or hearing) or the transport of fluids in complex tissue structures. Medically related physics is concerned with the study of muscle contraction, as well as the physical properties of the heart and the cardiovascular system. New trends in these areas concern the application of state-of-the-art lasers to illuminate elementary events in photobiology and the application of new microscopic techniques to study or manipulate single biomolecules. New microscopic techniques, often based on the application of lasers, are being developed for non-invasive imaging of biological events in living cells or organs. Mathematical modelling of the multitude of events in a biological cell, often coupled in a highly non-linear fashion, will lead to new emerging properties and is of crucial importance to biotechnology and molecular medical research (e.g. cancer research). The study of fundamental aspects of biomaterials and soft condensed matter will lead to fundamental knowledge about the physical properties of complex systems and new technological applications. Finally, knowledge of the information stored in the human genome will require the methods of physics, computer science, and (bio)informatics for its full scientific and technological utilisation.

The research activities in biological physics in the physics departments of the Norwegian universities are relatively small in volume, and are concentrated to three universities: UiO, NTNU, and the Agricultural University of Norway (AUN). The most active groups are involved in radiation biophysics and biopolymers, traditional areas in the field of biological physics. The other activities are scattered over various fields, and are often subcritical. Norwegian physics has missed the most recent and fast developments in this highly active field.

3.2.5 Condensed-matter physics/materials science

In the second half of the twentieth century, condensed-matter physics has emerged from being a relatively minor sector of physics at the beginning of the century to become by far the largest sector at the present time both in experiment and theory. The development of quantum mechanics, quantum-field theory, and many-body formalisms have been as essential in the evolutionary process of developing the present-day understanding of condensed matter as have been Röntgen's discovery of X-rays, the introduction of X-ray diffraction, and the liquefaction of helium, to name just a few.

The facts and consequences of the development of condensed-matter physics and related materials science are well known and everywhere visible in today's life. Superconductivity was discovered, semiconductor physics and magnetism were developed, leading to mile-stone technological inventions such as the transistor, the laser, magnetic data storage, microprocessors, personal computers, compact discs, satellite-based telecommunication, the internet, and the cellular phone.

There is considerable interest in the physics of soft condensed matter, a term that refers to a range of systems that fall between simple liquids and solids. Examples are liquid crystals, quasicrystals, glasses, polymers and biomaterials. New techniques for modelling complex disordered materials have been developed. The materials are of fundamental interest and have also large commercial implications.

The success of condensed-matter physics/materials science has turned the iron age into the silicon age we are presently living in, with global telecommunication and almost instant access to global information. And the development of condensed-matter physics/materials science is not at all over: We are just in the middle of the evolutionary process as can be inferred from such breathtaking discoveries in the past two decades as the quantum-Hall effect, high-T_c superconductivity, giant magnetoresistance, and scanning-probe microscopy. We are actually at the beginning of a development in materials engineering, where materials with special properties for almost any purpose can be custom-manufactured.

Condensed-matter physics/materials science is at present underrepresented in Norway's physics research. Experimental condensed-matter physics is pursued at two universities in Norway (NTNU, UiO), with additional minor activities at Stavanger College (one associate professor) and at the research reactor situated at the Institute for Energy Technology (IFE) at Kjeller. The overall staff amounts to 18 professors/associate professors at universities and five scientists at Kjeller. Theoretical condensed-matter physics is again pursued at these two universities (NTNU, UiO), with a total staff of 10 professors/associate professors being involved. This is indeed a small fraction of the total number of Norwegian physicists compared to international standards.

The larger part of the experimental research is related to structural work with rather classical and well-established methods, which are not at the forefront of present-day research. There is a small, reasonably focused surface-physics activity at NTNU, but most of the condensed-matter research at UiO and NTNU is rather unfocused and little co-ordinated. Most of the main research fields in condensed-matter research are not at all or poorly represented in Norway, at least in experimental activities, e.g. semiconductor physics, solid-state magnetism, low-temperature physics, and the science of nano-scale materials.

3.2.6 Space physics

Space plasma physics is a relatively new field of physics. It started with an exploratory phase in the early 60s, when rocket, satellite, and ground-based observations became available to understand the basic structure of near-earth space and, later, of other planets. Nowadays, our knowledge of the static magnetospheric structure of the earth and other planets is rather complete. Magnetospheric research now concentrates towards the study of magnetospheric dynamics and of the physical processes in the magnetospheric boundaries. Under the new heading of “Space Weather”, transport, storage, and transformation of energy in the magnetosphere as well as the coupling between the heliosphere, the magnetosphere, and the ionosphere are extensively studied.

Satellite measurements in space as well as ground-based measurements of the ionosphere are still the basic tools of research in space physics. In magnetospheric physics, space-born measurements will from now on be done mainly by fleets of spacecraft (to distinguish between temporal and spatial variations). The first of such missions is ESA’s CLUSTER-II. On the ground, global networks of instruments have been developed to co-ordinate different types of measurements. Both EISCAT and the new radar station on Svalbard are part of this network.

Within the relatively new framework of space weather, space plasma physics moves, at last partially, from basic science to more applied research. Good space weather predictions are important especially for the Nordic countries, where the effects of space storms are directly felt on, for example, power cables and pipelines. Space physics is also an important instigator for the evolution of space technology.

Due to its location, with its northern part under the auroral oval and Svalbard under the polar cap and cusp, Norway has a long tradition in space physics. Space physics in Norway comprises magnetospheric plasma physics, ionospheric plasma physics, and middle atmosphere physics. Included here is also laboratory plasma physics. Solar physics and dusty-plasma activities are described in the astrophysics section. There is essentially no activity in planetary physics.

All four Norwegian universities, (UiO, UiB, NTNU and UiT), UNIS (University Courses on Svalbard), and a research institute (the Norwegian Defence Research Establishment - FFI) are engaged in space and plasma physics, with a total of 22 faculty at universities and UNIS and five permanent staff at FFI. Magnetospheric physics is done at UiO, UiB, UNIS, and FFI, ionospheric physics at UiT and FFI, and middle atmosphere physics at UiO, UNIS, and FFI. Laboratory plasma physics is done at UiT. There is strong international co-operation, and most groups are engaged in international projects (ESA and EISCAT).

3.2.7 Subatomic physics

Elementary particle physics comprises research about the smallest constituents of matter and the forces that determine their interactions. The striving of experimental particle physicists to observe smaller and smaller structures demands larger and larger accelerators, the costs of which necessitate international collaborations. During the past 25 years, theory and experiment together have increased our knowledge about nature dramatically and the synthesis of this knowledge is the Standard Model (SM). The last decade has seen a consolidation of the SM in a series of precision experiments mainly done at CERN’s Large Electron-Positron Collider (LEP). However, it is apparent that there are fundamental aspects of nature that are not described by this model. There is every reason to believe that new exciting phenomena will be observed at CERN’s Large Hadron Collider (LHC) that will be the world leading instrument to investigate these very small-scale lengths.

There are, however, aspects of the SM that cannot be studied at the LHC. For instance the SM predicts neutrinos to be exactly massless, but there are now several experimental indications that neutrinos do have mass. Confirmation of these results would not only be an exciting discovery of elementary particle physics, but would also have impact on cosmology and astrophysics. A sensitive way to search for small neutrino masses is to look for evidences of spontaneous oscillations between neutrinos of different types (so called flavours). Evidence for oscillations exists from experiments in which neutrinos produced in nuclear reactions in the sun or by cosmic rays entering the atmosphere are studied. Neutrino oscillations will soon be investigated in new types of experiments where neutrino beams are directed towards dedicated underground facilities in Italy, Japan and United States.

An atomic nucleus is a complex many-body system. Basic questions in present-day nuclear physics concern the understanding of the nucleon-nucleon interaction on the basis of quantum chromodynamics (QCD) and the modification of hadron properties in the nuclear medium. Knowledge about nuclear matter is essential for our understanding of basic astrophysical and cosmological processes like nucleosynthesis, supernova explosions, the formation of neutron stars, and the processes that took place after the big bang. High-energy nuclear physics focuses to a large extent on this last issue, i.e. the quark-gluon plasma.

Many laboratories throughout the world are dedicated to the production of exotic nuclei far from beta-stability for studies of nuclear structure at extreme conditions. There are also experimental facilities exploiting cooled beams for precision experiments. Superheavy elements have been produced up to mass number 118. Applications of nuclear physics are found e.g. in medicine and biology and trace element analysis is an important tool in archaeology as well as in geology and climatology.

Experimental particle physics and high-energy nuclear physics in Norway are mainly focused on large experiments in international collaborations that exploit CERN facilities. The groups from the universities in Oslo and Bergen contribute to the same CERN experiments and share common responsibilities in order to maximise the impact of their contributions. The groups have competence in the instrumental part and in the data analysis and contribute visibly to the preparation of the experiment, to data collection and to data analysis. The experimental particle physics activity (11 staff) is centred around the DELPHI experiment at LEP and on the preparation of the ATLAS experiment at LHC. In addition there is participation in the BABAR experiment at SLAC, in the HeraB experiment at DESY and also in the continuation of the analysis of the data from CERN-SPS. The high-energy nuclear physics program (4 staff) comprises the analysis of the heavy-ion collision data collected at the SPS and the preparation of the ALICE experiment at LHC. In addition, the group participates in the BRAHMS project at Brookhaven.

A group at the Department of Physics, University of Oslo, is active in low-energy nuclear physics (5 staff). This group studies nuclear structure at low spin and high excitation energy at the Oslo cyclotron. Group members are active in international collaborations like the European EUROBALL project for studies of nuclear structure. An interesting activity in solar energy physics has been developed by members of the Nuclear Physics group in Oslo.

3.2.8 Theory

Today theoretical physics is a broad subject, with strong connections to various sub-fields of physics. It is a fertile source of powerful techniques of broad applicability both in physics, in other areas of basic research, as well as in the world at large.

Many theoretical techniques can be applied in a variety of contexts. For example, quantum field theory, which was developed to treat problems in particle physics, has been widely used in condensed-matter physics and nuclear physics. Consequently, classifying theoretical work according to the traditional sub-fields of physics does not give an accurate picture. Another example is studies of statistical physics. Many of the techniques in the subject were honed in studies of problems in condensed matter physics, but they have found applications in other areas, both within physics and beyond. Among areas of basic science in which the methods of statistical physics have been applied are studies of biological systems. Two broad classes of such biological problems are the description of biological matter, and the development of models of how biological systems function, for example how signals are processed in the brain. Further applications of the methods have been used for studies in materials science, in economics, and in finance.

One important development during the past two decades has been the enormous increase in available computer power, which has made it possible to model complicated phenomena on the computer. These studies occupy a middle ground between theory and experiment, and again the range of problems that can be addressed is vast. Numerical simulations play two roles in physics: on one hand they enable theoretical results to be compared with experiment to a greater degree of precision, while on the other hand they can reveal qualitatively new phenomena, which demand to be explained theoretically.

In Norway research in theoretical physics is carried out at all universities with UiO and NTNU having the largest number of theorists. The research interests in theory extend over many different sub-fields of physics, including condensed matter physics, statistical physics and the theory of complex systems, nuclear physics, elementary particle physics and field theory, and atomic and molecular physics. Theory in astrophysics and in space physics has been covered in the sections on those subjects. In the various centres, a number of scientists carry out studies that exploit numerical simulation.

The theorists actively engaged in research have almost without exception strong contacts to groups outside of Norway. Progress in theory occurs rapidly, and such links are essential for creating and maintaining a productive scientific environment. One striking feature of theoretical physics in Norway is the relatively large number of theorists who have little scientific collaboration with colleagues within their home institution or even inside the country, and who appear to work largely in isolation. There are exceptions, the most prominent being the Condensed-Matter Physics and Statistical Physics group at NTNU. This has proved to be attractive to younger scientists, and there is an openness to take up new problems. The strong group in Trondheim is continuing the tradition for excellence in theoretical physics built up there by professor Harald Wergeland.

The physics of complex systems is one area where in Norway there is particularly good synergy between theory, numerical simulation, and experiment and there are strong groups at UiO and NTNU. Part of the success of the effort in the physics of complex systems is due to the fact that many of the questions addressed have an obvious relevance to real-world problems, such as the study of porous media, which is important for the oil industry. This has made it possible for these groups to obtain significant funding from sources other than the Research Council.

3.3 Remarks on the funding of Norwegian physics

The funding for the university departments and research institutes that have been evaluated is accounted for in the tables in volume II of the report (figures for 1997). For the four universities, UiO, UiB, NTNU, and UiT, the numbers in the tables have been provided by the Norwegian Institute for Studies in Research and Higher Education (NIFU). For the other institutes the numbers have been provided by the departments.

The total funding for the Norwegian departments and institutes as accounted for by NIFU originates to one part from the General University Fund (GUF) and to the other part from external funding. The GUF resources go to a large extent to salaries. In order to account for how much of the GUF money that is spent on research, NIFU has used information about teaching loads and subtracted parts of the salaries that are not considered to be spent on research. In the oral presentation of the funding by the representatives from the departments and institutes, the amount of GUF-money generally was larger than is presented in the tables in volume II. The explanation of the discrepancy is that in the figures presented by the representatives of the scientists, full salaries were generally included without any correction for teaching. It should be noted that no rental costs are included either in the figures presented by NIFU or in the figures presented by the representatives for the scientists. Representatives for the departments and institutes let us know a number of times that in their opinion, the total funding for research is very low compared to other countries. To get a better understanding of the economic conditions for Norwegian physics, the accounts for a number of Swedish university departments (Uppsala, Stockholm, Gothenburg) and one representative department in the Netherlands (Amsterdam) were collected. The interpretation of the information and mutual comparisons are difficult as the figures provided by the universities in Sweden and the Netherlands are not directly comparable either with each other or with the figures from NIFU. For instance, the Swedish and Dutch figures contain salary costs for teaching and rental costs. It is not a straightforward procedure to correct for the differences between the departments or between different countries. A reliable comparison requires a careful and time-consuming analysis. The resources for doing such an analysis were not available for the committee, and therefore we chose to not publish the figures in this report as they easily can be misinterpreted. We recommend, however, that such an analysis be undertaken in order to establish a baseline by which the funding level of Norwegian science can be judged in a definitive way.

We limit ourselves here to making some remarks. It is clear that the money available per tenured faculty member in Norway is less than what is available in Sweden. The difference is however less than 50% of the figures relevant for Norway. The money/staff member in the Dutch university department seems to be roughly 100% larger than the Norwegian values. The number of Ph.D. students (dr.scient. students) per tenured scientist in Norway is smaller than in Sweden and especially in the Dutch department, indicating that the staff members in the Norwegian departments and institutes could devote more time in the future to the supervision of Ph.D. students. In Norway, however, the cand.scient. students participate to a certain extent in the research - probably more than what diploma students do in Sweden and the Netherlands. If the funding is normalised to the total number of graduate students (dr.scient. + cand. scient) the money per student will be very small in Norway. We have no data for normalising to the sum of Ph.D. and diploma students for the Swedish university groups, nor for the Dutch groups. As can be inferred from this discussion, a quantitative comparison between university departments in many of the Swedish and Dutch institutes cannot be made easily.

The evaluation committee is of the opinion that there is relatively little money available for the existing tenured staff in Norway. We would welcome increased support to the groups during the coming years, especially for equipment and for so-called “free projects”. This would help speed up the process of obtaining a more modern profile of physics research in the Norwegian universities and research institutes. On the other hand, it is apparent that the funding of the groups in Norway is very much fragmented and diluted by small grants to many scientists. Relevant to the last observation we propose that the Research Council and the steering boards at universities and research institutes, within a short time develop processes and mechanisms to define long-term strategies and priorities. Such procedures should give possibilities to concentrate support to the best activities, and to redirect resources now tied up in positions for professors who are not working in very coherent research constellations, but can be set free when retirements occur**.** The evaluation group strongly advises that resources be moved from tenured staff positions to Ph.D. fellowships and to career positions for young scientists. A combination of a (moderately) increased economic support to stimulate restructuring procedures and a well-organised work for creating research strategies on a national level as well as in the departments and institutes, would put Norway in a much better situation. The relatively large number of retirements during the next 5-10 years should offer realistic possibilities to carry through a successful change.

The evaluation committee is, however, concerned about the possibilities for acquiring new instrumentation. The small amount of funds for equipment effectively hampers initiatives to create environments centered around internationally-competitive instruments. The annual budget for the whole scientific field covered by the Research Council of Norway is 25 MNOK. In addition to that, the Science and Technology Division of the Research Council contributes with 10 MNOK in the budget for 2000. The evaluation committee finds it very important to increase the funding for equipment. At the same time we strongly advise that investments in equipment be strongly coupled to strategic long-term planning, and that such investments should be combined with creating strong research environments.

The evaluation committee finds the special budget of the Science and Technology Division for five-year programs for basic science interesting. We are, however, concerned about the mechanisms for continuation or termination of the programs. We advise that such programs should be supported by the budget of the Research Council normally only for one five-year period, and that mechanisms which allow for the planning of the continuation of successful programs – and termination of unsuccessful ones – after the first five years should be created. The continuation of the successful programs should preferably be planned by restructuring resources within the universities. In exceptional cases if successful programs run the risk to decline, the Research Council should continue the support with a special budget for at most a second five-year period. The committee finds the termination of the program for materials science to be an instructive example of how not to deal with such special programs: We found no evidence for a serious evaluation of the success (or failure) of the program; nor did we find evidence that serious long-range planning for the future of the program beyond the termination of its funding had been done. Especially lacking was a productive interaction in long-range planning between the Research Council and the affected university groups. Since the Research Council, in concert with the universities, completely dominates the funding of research in Norway, such long-range planning interactions between working scientists and the Research Council are essential, and very stongly urged by this committee.

3.4 The human capital

3.4.1 Personnel structure

The personnel structure in the Norwegian university departments is extremely top-heavy with a large number of professors and with a majority of tenured staff. In addition, the staff of the physics departments of the major universities has an age distribution with a considerable number of persons that will retire within the next 10-year period. Few fellowships for postdoctoral studies abroad are available and in addition the ambition of Norwegian students to spend a couple of years abroad seems to be rather low. A big problem is that there are few postdoctoral positions in Norway. The evaluation committee has the impression that the salary level for the large number of professors is low and non-differentiated, i.e. there is no merit-oriented incentive for raising of salaries. There are four apparent conclusions to be drawn about this situation:

- There is a clear risk of a drain of competence from the universities in the near future, when staff are retiring, if no measures are taken.
- The attraction for young talented persons to start a university career in physics must be considered low.
- Norway can, however, take advantage of the situation to redirect some of the resources now tied up in the large number of permanent staff towards postdoctoral fellowships and postdoctoral positions and create a clear and visible career system.
- There is a good opportunity to phase out stagnating and non-focused activities and redirect human resources towards new areas of research.

3.4.2 Faculty age distributions

The age distribution at the physics departments at Norwegian universities can be divided into two categories, the older institutions, Oslo, Bergen and NTNU and the newer ones.
Rather than giving the full data for each institution, we have chosen to present a few key numbers. We have excluded UNIS (with only two staff members both non-tenured), and we have also left out IFE and FFI except in the table below. In the table the name of the institution is given in the first column, the number of tenured staff is given in brackets, the mean and median ages and the fraction of tenured staff to retire within the next ten years in the last column. Tenured staff is generally between the ages of 35 to 70, with one or two people below the age of 35. In an age distribution with a few staff members below the age of 35 and the rest of the staff ages uniformly distributed, the mean and median ages would be 51.5 years. The fraction to retire within 10 years would be 26%.

Institution (number of faculty)	Mean age	Median age	Fraction to retire within the next 10 years
UiO Physics(57)	55	56	39%
UiO ITA(10)	55	59	40%
UiB(36)	55.5	58	44%
NTNU(46)	56	58.5	48%
UiT(18)	48.9	48.9	11%
AUN(10)	45.3	46.5	10%
Stavanger(8)	48.8	51	0
IFE(5)	50.8	43	20%
FFI(6)	43.8	41.5	17%

What is immediately apparent is that there are two major groups of institutions, one with older staff and one with younger. The mean and median ages are fairly equal except at ITA. The faculty members at the universities in Oslo, Bergen, and Trondheim have a higher mean age than at the other institutions. At these universities, a substantial fraction of the tenured scientific staff (between 40 and 50%) will retire within the next ten years. At the Department of Physics in Oslo there is a small gap in the age group 41-45 years while the rest of the distribution is fairly uniform. ITA has a small staff and with the characteristic that at present there are no staff members with ages between 46 and 55. In Bergen one has not started hiring tenured staff below the age of 36 yet; there is a peak between ages from 61 to 65 and a gap between 46-50. NTNU has a large number of faculty members with ages 61-65, a gap in the age region 46-50, and very few staff members with ages below 40.

At Tromsø, AUN, and Stavanger the situation is different. Only a small number of staff members will retire within the next ten years, and the age distributions are rather scattered with a considerably younger mean age than in Oslo, Trondheim and Bergen.

3.4.3 The missing career path

There is presently little Norwegian support for postdoctoral studies abroad and there are very few openings for time-limited positions in the Norwegian departments and institutes. This situation cannot be very stimulating for talented young people to consider university careers. There seems in general to be a rather small interest from fresh Ph.D.s in physics to spend a postdoctoral period abroad and then return to Norway with new experiences and ideas. The evaluation committee has the impression that the physics community in Norway is well aware of the situation and concerned about it. However, no general plans solving the problem were presented. In the discussions with the evaluation committee, several of the representatives of the universities and institutes were in favour of considering the redirection of resources, now tied up in permanent positions, as soon as they become available for creating postdoctoral programs and visible career paths for young scientists.

3.5 Strategy considerations

The written background material for the evaluation contains sections about future plans and scientific strategies. The depth and wealth of details vary between the departments and institutes. The evaluation committee finds it important to understand possibilities and readiness to change the fragmented group structure existing in several of the places. Also the possibility to redirect resources from existing fields to new fields is a concern for the evaluation group. One of the topics discussed between the evaluation committee and representatives of the Norwegian physics institutes in the meeting at Gardermoen concerned strategies for future developments.

The evaluation group has the general impression that the departments and institutes are aware of the strengths and weaknesses of Norwegian physics research. These include the rather large resources directed towards participation in international large-scale projects in astronomy, high energy physics and space physics, as well as the trend lately to direct resources away from basic physics to applications. The situation in the near future, with the many retirements, offers possibilities for changing group structures, the career pattern, and research fields. Most of the representatives of the scientists that we met had recognised this.

With a few exceptions, however, long term strategies presented were not very focused and not concrete enough as far as possible changes are concerned. No doubt, there are plans for continuations and developments in the same scientific directions as present, but we could not find any strongly formulated intentions to create mechanisms for a better career system or for starting up some new fields that are missing in Norway. Instead we often found a resignation in the attitudes. An opinion of a locked system with political decisions to participate in international big science programs in astrophysics, high energy physics and space physics was often expressed. It was also often stated that the Research Council sets higher priority on research leading to fast applications than on basic research.

The evaluation group has clearly identified that the fields of astronomy, high-energy physics and space physics have much more coherent activities, focused plans and visible long term strategies than other fields. It is apparent that the strong international collaborations have forced the Norwegian communities to co-operate and to work out plans for concerted Norwegian actions to participate in selected international big science projects. Instead of being critical of fields having a large element of international collaborations, it is recommended that the university departments and research institutes as well as the Research Council learn from the development of these fields. It is necessary for a small country like Norway to create research constellations with strong international contacts and which are large enough to compete successfully on the international level. As is elaborated in more detail in chapter 5 of the report, the evaluation committee recommends that the university departments, research institutes and the Research Council work out a scheme for creating, and continually updating, long term strategies for the future. Such strategies should include career systems, positions, development of existing fields, phasing out of fields and creating new fields.

One of the main problems in physics research at Norwegian universities is the lack of scientific collaboration between individual groups of a given department and the lack of common research goals pursued by different groups and researchers at the same location. This causes the existence of rather diverse and unfocused research activities in those fields of research that are not bound into international large-scale facility programs. This situation must be changed in due course by appropriate and effective incentives and measures of the Research Council in close collaboration with the universities. In addition to the existing basic research programs, which are commented upon in section 3.3 and later on in the present section, the evaluation committee suggests two ways for changing the present rather detrimental situation:

(i) The funding agency should preferentially support groups of researchers at a given institution whose members focus their research activities around a common theme in an active area of the field acknowledged by an international board of referees installed by the Research Council.

(ii) Researchers from all over Norway should be encouraged to make proposals for "special research units" (cf. German "Sonderforschungsbereich"), which upon approval by an external board of referees will be funded for periods of three years each. A program could be renewed and extended for additional periods upon recommendation of an international evaluation panel. The total period for which such a special research unit can be funded should not exceed 12 years.

All of these focused research activities should be additionally funded by the universities or research institutes with special research budgets dependent on the amount of money gained by each individual project. This would additionally stimulate research in focused and acknowledged research fields, with particularly great advantages for the graduate students.

The evaluation committee commends the fact that the Research Council started to support so-called basic research programs several years ago. However, this is a promising approach to re-invigorating Norwegian science only if it is part of an integrated long-range plan for inserting successful strategic programs back into the mainline Norwegian research programs. In fact, we have noted a near-total absence of long-range strategic planning of this sort; this absence was exemplified by the recent interruption of a successful materials science basic research program, which we would have expected to have been continued as part of its re-integration into the regular research program, after its five-year period as a basic research program. In this particular case, the evaluation committee is concerned about the apparent risk that the important field of materials science may disappear after some years. In order to avoid such debacles, there is a need for the Research Council and the university groups to collaboratively develop long-term strategies for re-integrating successful basic research programs into the regular university programs; this will require a willingness for incremental funding on the part of the Research Council, and a willingness on the part of the university community to re-direct some of its research programs in response to the introduction of new research directions. Unless this is done - and we saw little evidence that it is being done - the funding of basic research programs will be largely wasted.

The evaluation committee is strongly in favour of bottom-up processes in working out strategies. There should, however, be procedures and conditions defined by the governing bodies of the university departments and research institutes in close collaboration with the Research Council, which forces and stimulates the scientific communities to increase international collaborations, to join forces and to focus on relevant research fields.

4 Evaluation of departments and institutes

4.1 University of Oslo

The Department of Physics and the Institute for Theoretical Astrophysics have been evaluated by the committee. In volume II, the research activities are presented in detail.

4.1.1 Department of Physics

The staff at the Department of Physics at University of Oslo comprises 39 professors, 11 adjunct professors and 21 associate professors/lecturers. The department is organised in eight research groups. About 20 persons of the staff are involved in programs within large international collaborations like CERN and ESA.

The number of students has decreased by about 50% since 1993 but there is a significant increase in 2000. About 1/3 of the scientific staff will retire in the next 10 years, especially in the groups with the largest number of staff. This is an opportunity to revise and renew the scientific program of the department if the recruitment is accordingly tuned. There is a fear that the budget, and in consequence the staff, may be reduced due to the reduction of students.

4.1.1.1 The Biophysics group

The faculty positions in the Biophysics group consists of two professors, Sagstuen and Pettersen, two associate professors, Vistnes and Hole, and one adjunct professor, Moan.
The research in the Biophysics group has covered the following three areas: Low frequency electromagnetic radiation, UV radiation and ozone and Ionising radiation. In the following the main activity in these sections will be shortly discussed.

<u>Low frequency electromagnetic radiation</u>

The research concerning low frequency electromagnetic radiation (associate professor Vistnes) as reported between 1994-1998 involved the statistical analysis of the effects of low frequency electromagnetic radiation fields (power lines, high voltage test laboratories, display units etc.) on health in general and the incidence of certain forms of cancer in particular. Publication of the results is in highly specialised journals, outside mainstream biophysics. The cancer related work is to some extent internationally recognised. The overall rating of the work is fair.

<u>UV radiation and ozone</u>

A major part of the research involves a high-school oriented project to measure total solar energy at ground level and in some cases atmospheric ozone. There is a collaboration with the Plasma and Space Physics group concerning the measurement and analysis of atmospheric ozone and with the University of Alaska at Fairbanks concerning the measurement and modelling of UV. There are no publications in this area.

<u>Ionizing radiation</u>

Sagstuen and Hole work together closely, and their research concerns mainly the mechanism of radiation induced damage in biological macromolecules, mainly DNA. The group specialises on ESR and ENDOR. There is a project on ESR-dosimetry with possible medical relevance. The work of Sagstuen/Hole lies in the Radiation research/EPR community and is in the periphery of the international biophysics community. Sagstuen/Hole publish regularly in international journals. The work is internationally visible and its overall rating is very good to good.

The work of professor Pettersen generally concerns the effects of ionizing radiation on cells, the roles of oxygen and oxidative stress (the latter in relation to environmental factors). In addition Pettersen is involved in studies of cancer prognosis using flow cytometry. The work is strongly medically/cell biologically oriented. Pettersen publishes actively, in international journals largely outside the biophysical area and not with the other members of the Biophysics group at UiO. The work is rated as good.

Assessment

The research in biophysics is productive, but not of high impact, and it is largely outside the major international activities in biophysics. Part of the research might be too strongly medically/biologically oriented to be categorised as physics.

Biomolecular science elements in the work of Sagstuen/Hole can be identified. The EPR/ENDOR facility operated by the group is of international level. The group attracts a significant number of undergraduate students.

Recommendations

Since the next decade will show the integration of physics, biochemistry and molecular biology it is advised to strengthen biophysics at UiO with one to two persons active in molecular/cell biophysics/physics of biocomplex systems. A new experimental biophysics activity, for instance based on the application of advanced laser techniques, seems an appropriate choice.

A research/training program in biomolecular sciences in the Faculty of Mathematics and Natural Sciences together with the chemists, biologists, etc. should be initiated and the EPR/ENDOR operation should at the same time be upgraded into a national multidisciplinary facility open to physics, biology, chemistry, and medicine.

The research in “low frequency electromagnetic radiation” and “effects of ionizing radiation of cells etc.” should be discontinued.

4.1.1.2 The Electronics group

The Electronics group, with two professors (Finstad, Skaali), four associate professors (Lindem, Martinsen, Midtun, Sveen), and four adjunct professors (Hanneborg, Kristiansen, Øhlckers, Seim) is carrying out rather diverse applied physics projects, which are closely related to the needs of external companies or institutes that are interested in the results from the application point of view.

From the material available, two of the activities can be judged as good, what the scientific or technical output is concerned, namely the work connected with the DELPHI collaboration at CERN in the field of measurement/instrumentation/data acquisition by professor Skaali and the very application-oriented work on sensors by professor Øhlckers, who is also president of the Microsystem Company 54.7. The scientific outputs of professors Martinsen, Finstad, Midtun, and Lindem are judged as fair, while those of professors Hanneborg, Kristiansen, Sveen, and Seim are rated as poor.

Assessment

In general, the very application-oriented work of the Electronics group has a low physics profile, but seems to be attractive to cand.scient. and dr.scient. students due to the applied aspects and possibly due to the job opportunities in these fields. This, however, has the consequence that the research activities of the individual members of the group are dominated by individual choice, and as a whole rather unfocused and disperse, lacking the critical mass that would be necessary for a wider impact.

Recommendations

The work in collaboration with CERN projects on data acquisition should be continued as well as the activities in hydroacoustics. The research activities on physical electronics, in particular on metal-semiconductor junctions, have had little scientific impact in the past and should be phased out. The biomedical engineering activities are also very isolated and could be transferred to strengthen the biomolecular research.

4.1.1.3 Experimental Particle Physics group

The permanent staff of the group consists of five professors (Bugge, Buran, Jacobsen, Read, Stapnes) and one adjunct professor (Weilhammer). At present there are six doctoral students and four cand.scient. students.

The main activity of the group (professors Bugge, Buran, Read, Stapnes) is centred around the DELPHI and ATLAS experiments at CERN in close collaboration with the Bergen group. In the DELPHI experiment the group contributed to the construction of two luminosity monitors (SAT and STIC) that have been instrumental for the precision measurement of the Z boson line-shape. The activity is now concentrated on analysis. The main analysis topic is the search for the Higgs boson, one of the most relevant analyses at LEP2. The Oslo group has proposed the adopted method for the combination of the results of the four LEP experiments on the search for the Higgs boson.

The activity in ATLAS is focused on the inner detector (ID). The Oslo group has contributed to the design in collaboration with local industries and also, to the electronics, with the Department of Informatics. They have, in collaboration with Bergen and Uppsala, the responsibility to construct one layer of the silicon barrel. This project is well dimensioned to the size of the group. In Oslo a clean room has been built and equipped for the construction of silicon detector modules. The ATLAS activity is supported by one (out of three) electronic engineers and by 30-40% of the manpower of the mechanical workshop. Professor Stapnes is the leader of the ATLAS ID project, a position of great responsibility and visibility (the ATLAS project has about 15 subprojects, among which the ID is one of the most complex).

The analysis of the WA102 data for the search of glueballs is the main topic of research of professor T. Jacobsen. It will be completed during 2001.

Professor Buran participates in the HeraB experiment at DESY. He has contributed to the construction of part of the detector including part of the mechanics of the Outer Tracker.

Assessment

The contribution to the CERN program is rated very good and is healthy: the participation in DELPHI is focused on important analysis topics and the future participation in LHC physics is in the hand of young and motivated people. The group is well visible inside the ATLAS experiment and has a defined hardware contribution as its flagship program. The hardware responsibilities have been chosen to guarantee an important return to local industries. The expertise gained in the analysis of LEP data and the important contribution to the ATLAS hardware will allow Norwegian physicists to play a central role in the exploitation of the LHC data.

HeraB is scheduled to take data in the year 2000, after a problematic phase of construction and commissioning. The participation of the Oslo group in this large collaboration is very limited and thus its impact relatively small.

Recommendations

It is important that the support to the ATLAS group remains adequate also in the near future, in the critical phase of construction, assembly and preparation of the data analysis.

The participation to HeraB should be either discontinued or substantially increased. The group should weigh the advantages of an increased participation to HeraB against the disadvantages of a reduction of the impact on ATLAS.

4.1.1.4 Solid State Physics group

The Solid-State Physics group consists of eight professors (Amundsen, Feder, Galperin, Johansen, Jøssang, Lothe, Måløy, Nøst), two associate professors (Baziljevich, Bratsberg), and three adjunct professors (Aharony, Giaever, Skjeltorp). At present there are three doctoral students in the group.

The research comprises both theoretical and experimental studies and is rather diverse, including theoretical studies on mesoscopic systems (Galperin), experimental work on high-T_c superconductivity (Baziljevich, Bratsberg, Johansen), theory of elastic anisotropic media (Lothe), as well as theoretical and experimental work on disordered and complex systems (Feder, Jøssang, Måløy, Nøst). In general, the scientific output of this group is very good, with four researchers standing out with excellent results in the past-five-year period: Feder, Jøssang, Galperin, and Johansen. Also Jøssang, Lothe, and Måløy have contributed with high-impact papers to this field in the past. The research records of Amundsen and Nøst have been fair to poor within the past five years. There are collaborations between theorists (Lothe and Galperin) and experimentalists (Johansen, Bratsberg, and Baziljevich) in this group particularly in the field of flux pinning in superconductors.

Assessment

The scientific output of the group is generally excellent to very good, and there is some close collaboration between experiment and theory. Feder and Jøssang have played leading roles in the scientific success of this group in the past. As a whole, the research program of this group, however, is relatively disperse and not focused enough. The experimental activities are relatively limited from the spectrum of available methods and cannot quite cope with some of the high-impact theoretical work going on. There is clearly a lack of young scientists on the tenure-track or postdoctoral level in this group.

Recommendations

Since several retirements will occur in this group within the near future, the chances should be used to start a new promising activity in experimental solid-state physics that fits well into the existing research spectrum. The committee recommends to consider the science of semiconducting materials, a field that is practically absent from physics research at Norwegian universities. In addition, the existing successful research activities in the fields of disordered systems and flux pinning in high-T_c superconductors should be carried on. As job openings occur through retirements, the theoretical activities should be further strengthened by recruiting promising young faculty members on the basis of international searches.

4.1.1.5 Nuclear and Energy Physics group

The Nuclear and Energy Physics group consists of seven professors (Engeland, Guttormsen, Ingebretsen, Løvhøiden, Osnes, Rekstad, Tjøm), four associate professors (Gjøtterud, Hjorth-Jensen, Messelt, Tveter) and one adjunct professor (Strand).

The research of a theory group, Engeland, Osnes, Hjorth-Jensen, covers nuclear physics and nuclear astrophysics, ranging from nuclear structure studies to the structure of neutron stars. A common theme is a macroscopic description within the framework of many-body theories, of the interactions between hadrons. Hjorth-Jensen has a very good publication frequency. The research of the theory group is judged as good.

A multi-detector system for gamma rays and charged particles is used for studies of nuclear structure at low spin and high excitation at the Oslo cyclotron. The work is conducted by professor Guttormsen. The publication record is good to fair. The detector-development work is of good quality.

Members of the Nuclear Physics group (Ingebretsen, Tjøm, Tveter) work with low energy structure studies within international collaborations. They have not had leading roles in the collaborations. The participating group members have the majority of their publications from this work. The publication record of Tjøm is good, while Ingebretsen has published with rather low frequency and his publication record is judged as fair. Tveter’s publication record is good. She has now joined the High-Energy Physics group.

A team from Oslo, led by Løvhøiden, participates in the big international collaborations for studying ultra-relativistic heavy-ion collisions with the aim to search for phase transitions of nuclear matter to a quark-gluon plasma. The Oslo group works in close collaboration with a group from Bergen in this program. At CERN, the Oslo group has participated in fixed target programs and is committed to the participation in construction of the ALICE detector for studying Pb-Pb collisions at LHC. For the period 2000-2005, when CERN will not provide beams for this type of research, the group will participate in experiments at RHIC (Relativistic Heavy Ion Collider), Brookhaven. The work is of high international interest and is judged as very good. The participation in the RHIC experiment in addition to the CERN activity is a natural choice in a scientific perspective, but the small size of the group gives reason to question the possibilities for the group to make good enough contributions both in LHC and RHIC experiments. It is, however, a clear advantage that Tveter has joined the high-energy group.

The radiation physics research is focused on radon in indoor air. It is a small activity driven by an adjunct professor in collaboration with the Norwegian Radiation Protection Authority.

A solar energy research program is lead by Rekstad. A solar energy laboratory has been built for experiments on solar heating and radiative cooling systems. The activity is industry oriented. It has been attractive for students. The publication record is fair. The group collaborates with large international companies. The program is judged as good.

Assessment

There is a problem with the diversified program within this group. The age structure of the group gives reasons for concern. The group has a very good activity in supervising cand. scient. students. Only four dr.scient. students, however, have graduated in the period 1994-1998. This is an extremely small number considering the relatively large number of professors in the group.

The theory group has developed useful techniques for calculating effective interactions in nuclei, and the broadening of their horizons to include astrophysical problems is welcome.

The costs of running the Oslo cyclotron are paid by the Department of Physics, despite the fact that most of the users come from the Department of Chemistry. The cyclotron is also used by the Norwegian Cancer Hospital. The nuclear physics program is of good quality, but it is narrow and cannot justify the operation costs of the cyclotron. In 1998 the cyclotron was used 1051 hours during 134 days for experiments, which indicates only daytime use, which is quite unusual for a facility like this. Only 52 days were used for experiments by scientists from the Department of Physics.

The evaluation committee is concerned about the possibilities for the small high energy nuclear physics group to carry through the ambitious program with demanding engagement in two big international experiments at CERN and RHIC, USA.

Recommendations

The diverse group should be restructured. The activities in nuclear physics should be focused on the participation in the international collaborations. The ultra-relativistic heavy ion program and especially the participation in the CERN program at LHC should have the highest priority. The evaluation committee recommends that the High-Energy Nuclear Physics group joins the Elementary Particle Physics group and that they form a new group for Subatomic Physics.

The low-energy nuclear physics activities should be phased out and the resources should be directed towards the high energy physics and the energy research programs.

The theorists in the group should be encouraged to turn their attention to other problems where they can make use of their experience. It is recommended that the theoretical activities within the Nuclear and Energy Physics group be moved to the existing Theoretical Physics group.

Energy research has high priority in Norway and the solar energy group is running interesting projects. The evaluation committee recommends that the group joins a new program on environmental and energy research within the department.

4.1.1.6 *Plasma and Space Physics group*

The Plasma and Space Physics group comprises eight permanent scientific faculty members, five of whom are close to retirement age. There are five professors (Egeland, Holter, Holtet, Pecseli, Sandholt) and three associate professors (Dahlback, Kildal, Tønnessen). The large fraction of staff close to retirement age poses a problem of continuity, but gives at the same time the opportunity for restructuring the group.

The group is engaged in four different research fields, two of which are related to large international programs (ESA and EISCAT).

<u>Basic Plasma Physics</u>

The theoretically oriented Basic Plasma Physics group has a strong leader of international standing (Pecseli), with one of the best publication and citation records during the past six years found in space plasma physics in Norway. The other member of that group (Kildal) is close to retirement and on the other end of the spectrum. Co-operation with the next subgroup is good and produces interesting and important scientific results.

<u>Satellite-based Studies</u>

The group for Satellite-based Studies has two members (Holtet and Holter), who both will retire during this decade. Holtet is also engaged in work covered by the Ground-based/Cusp Region group. Scientific productivity during the last six years has been good to fair. The scientific analysis side has to be strengthened by introducing new blood and by continuing the fruitful co-operation with the Basic Plasma Physics subgroup. On the hardware side, there seems to be co-operation with the FFI group (made visible by an adjunct professor position), but a lack of collaboration with the satellite experiment efforts of the Bergen group.

<u>Ground-based/Cusp Region</u>

After the retirement of professor Egeland, the Ground-based/Cusp Region group has only one full member (Sandholt). His publication and citation record comes close to that of professor Pecseli and he is also internationally recognised for his work. The successor of professor Egeland is a very promising young scientist (Moen), who has also worked in this field (see UNIS).

<u>Ozone/UV</u>

The Ozone/UV group has two members. The younger member (Dahlback) is active with a focus on the instrumental side. His scientific visibility and his work are rated as good. The older member (Tønnessen) is concerned only with observatory-type measurements.

Assessment

The satellite related work of the Basic Plasma Physics and Satellite-based Studies subgroups is good to very good. The work of the Ground-based/Cusp Region subgroup can be rated as very good, that of the Ozone/UV subgroup as good to fair.

Recommendations

Retirement and subsequent (partial) replacement offers the opportunity to strengthen and focus the group's efforts. For the next five years, the group should focus on harvesting their efforts put into the CLUSTER-II mission, which is to be launched this year. Since key science done with CLUSTER-II will be plasma physics of the cusp region, continuing the good collaboration between the first two subgroups and expanding that to cover the third subgroup should inevitably produce interesting scientific results.

In the long run, the group should concentrate more on satellite studies. The theoretically supported data analysis is on a good track, but satellite hardware efforts at UiO are presently at too low a level. A possible remedy would be either to strengthen the co-operation with the FFI and especially the Bergen group or, even better, to establish a vigorous hardware program.

For continuity reasons (new satellites do not come very often) some ground-based observations should be kept, others gradually shifted to the UiT and UNIS groups, but close collaboration is encouraged. For even more synergy effects, closer co-operation with the Solar Physics group of the ITA seems advisable, both in hardware efforts and theory.

The Atmospheric subgroup seems subcritical, but strengthening of this subgroup could endanger the excellent outlook for the rest of the group within the limited resources available. It may be advisable to move the Ozone/UV work to an Environmental Physics group to be established.

4.1.1.7 Structural Physics group

The Structural Physics group consists of two professors (Olsen and Taftø) and one adjunct professor (Andersson). The activities of professors Olsen and Taftø are part of the Centre for Materials Science at the UiO, where also groups from the Department of Chemistry are involved. The research is centred around several transmission microscope and one scanning electron microscope in the Centre for Materials Science, including instruments for Auger-electron and photoelectron spectroscopy, atomic-force microscopy as well as metallographic studies. Both researchers are mainly involved in applications of electron microscopy: Professor Olsen's work is mostly concerned with standard applications of this technique, with an overall output that can be judged as fair. More innovative applications are followed by professor Taftø, whose scientific output can be classified as good. Both researchers seem to make no use of the electron-spectroscopic facility and the atomic-force microscope available to them. At present the group employs three doctoral students, but no junior researcher.

Assessment

This is a rather small activity with good to fair research results, which seems to be quite isolated from the Solid-State Physics group.

Recommendations

A much closer collaboration of the Structural Physics group with Solid-State Physics is recommended. The activities on electron-energy loss spectroscopy with a TEM should be expanded in the direction of high-resolution work for elemental and chemical analysis.

4.1.1.8 Theoretical Physics group

The Theoretical Physics group has ten permanent staff members, eight professors (Aashamar, Eeg, Frøyland, Høgåsen, Leinaas, Lütken, Ravndal, Veseth) and two associate professors (Haug, Vøyenli); in addition there are two adjunct professors (Grøn, Lindström).

Theoretical physics at the University of Oslo covers a wide range of subfields of physics. About one half of the theorists are in the Theoretical Physics group, and the remainder are in groups with experimental activity. Within the Theoretical Physics group the main subjects under investigation are quantum field theory in particle physics and condensed matter physics (Leinaas, Lütken, and Ravndal), phenomenological subatomic physics (Eeg and Høgåsen), atomic physics (Aashamar and Veseth) and the physics of complex systems (Frøyland).

The overall publication records of Aashammar, Eeg, Høgaasen, Leinaas, Lütken, Ravndal, and Veseth are good, but Aashammar and Høgaasen have published less frequently over the past few years. As far as one can judge from the material submitted to the committee, the other faculty members have not been active in publishing research in recent years.

Despite the declining student enrolment in recent years, the group has continued to be successful in attracting good graduate students. During the period 1994-1998 10 dr.scient. degrees were awarded to students from the group, the majority of them working in condensed matter physics and field theory. Of these students four worked with Ravndal, who continues to play an important role in nurturing students by working with them on a diverse range of problems, and by encouraging them to gain experience at centres outside Norway. Among Ravndal’s former students one may mention four who have faculty positions in Norway: J. M. Leinaas and C. Lütken at UiO, and A. Hansen and J. Myrheim at NTNU.

Many members of the group have good collaborations with scientists at centres outside Norway, and especially Eeg, Lütken and Veseth have a number of publications written with collaborators from other institutes. What is noticeable is that apparently there is no collaboration among members of the group. One constellation where there appears to be scientific overlap is that of Leinaas, Lütken and Ravndal. In addition these people have a record of attacking diverse problems in the area of field theory and general theoretical physics, and have useful interactions with people at NTNU working on similar problems.

The contributions of the groups vary significantly. During the years for which data have been made available, most members of the group have had relatively stable profiles of interest.

Assessment

Some members of the group have made and are making contributions of lasting importance, and the members working on field theory and general theoretical physics stand out. However, the group as a whole is very inhomogeneous and lacks cohesion. Many members of the group seem to be scientifically isolated in the department, with their main scientific collaborators abroad. This makes it difficult to create active scientific environments at the home institution. Members of the group appear to have little scientific interaction with theorists in other groups at UiO, and such contacts could be useful and inspiring in areas such as nuclear theory, field theory, and condensed matter theory, where many of the same tools are employed.

Recommendations

In making future appointments, strong emphasis should be given to finding people who are scientifically of the highest standard and with broad interests and who will create a lively, interactive scientific environment. Support should be given to efforts to build up scientific collaboration within the group and with members of other groups, and to increase cross-fertilisation between different subfields. Consideration should be given to altering the present group structure with a view to encouraging collaboration.

4.1.1.9 Overall assessments and recommendations

The research at the Department of Physics at the UiO, with its division into eight groups, is rather divergent, with activities in too many different fields, which leads to a number of sub-critical research activities. The research at the Department of Physics should instead be concentrated to fewer programs, which reach critical mass and can give increased international impact.

This has been noted by the department, but no strategic plans have been developed to counteract this situation. Thus, immediate internal assessment of the department and the production of a medium/long-term strategic plan are of great importance. A number of retirements will occur in the coming years. The plan should define a clear strategy for using these resources within the physics department as a whole. Attention should be paid to taking this opportunity to renew and modernise the profile of the whole department rather than refilling vacant positions in traditional subjects.

The committee suggests the following specific measures:

- Space physics should be strengthened over the next ten years focusing the group efforts and including expertise in building space-borne instrumentation (see also sec. 5.9).

- The experimental low-energy nuclear physics should be discontinued, and the running of the cyclotron should be commercialised in the near future. Nuclear physics research should be focused on high-energy heavy-ion collisions. The activities on high-energy subatomic physics should be concentrated in one group that should be maintained at an adequate staff level to lead an important Norwegian experimental program in high-energy physics.

- Research in solid-state physics should focus on modern topics. Among areas where a growth of expertise is desirable is the physics of semiconducting materials.

- Biophysics should be strengthened by one or two staff openings in a new experimental activity based on the application of advanced laser techniques.

- A new program on environmental and energy research should be started.

- The theory group should be staffed at an adequate level and should become more integrated. In making future appointments, strong emphasis should be given to collaboration between the members of the group and with members of the experimental groups.

4.1.2 Institute for Theoretical Astrophysics

Institute for Theoretical Astrophysics (ITA) is the centre for astrophysical research in Norway, and is the only institute in Norway with a primary astronomical focus. The main lines of astrophysics research carried out at ITA include solar/stellar physics, cosmology (really, extragalactic astronomy), and celestial mechanics. The research effort is half theory and half observations; within the past few years, numerical simulations have begun to play an increasing role as a third mode of research.

The Institute has nine professors and one associate professor: six of the faculty pursue solar/stellar physics; two are extra-galactic astronomers, one is a plasma physicist, and one carries out research in celestial mechanics.

4.1.2.1 The ITA Solar physics program

ITA's solar physics program is strongly concentrated toward studies of the outer layers of the sun and involves theory and both ground and space-based observations. Current efforts focus on international collaboration with the ESA/NASA SOHO mission. A new lead project is the strategic program in large-scale numerical simulations (MAP), with participation from the physics department at UiO and FFI. In the future, the group anticipates participation with the Japanese/NASA Solar-B project.

Assessment

Our assessment of the ITA solar/stellar program is that it represents a strong activity on an international scale. The new MAP strategic program in computational solar physics is very promising, and deserves continued support. The publication record of two of the more observationally-oriented faculty (Kjeldseth-Moe, Maltby), and two of the theorists (Leer, Trulsen) is very good, while the others' (Engvold, Carlsson, Hansteen) publication record is rated good. Our summary evaluation is that their work, as individuals, ranges from good to very good; but as a group should be judged good. This group has developed a substantial scientific stature on the international level and plays a prominent role in international planning and advisory committees.

Recommendations

The Solar group's plan is to take advantage of their new efforts and strengths in simulations and modelling. This they plan to do by working at the interface between observations (ground or space-based) and theory. Given the level of investment at ITA in this field, we concur that these plans are a wise use of their limited resources. While we are of the wiew that the transfer of one position from the Solar to the Extragalactic program as part of a planned retirement can be carried out without damage to the solar program, ITA needs to make sure that the more observationally-oriented portion of the solar program remains strong as the simulation effort is built up. ITA needs to put in place a long-range plan for how the efforts now supported by the MAP strategic program will be re-integrated into ITA's regular research program, once the Research Council's support of the strategic program terminates. If this planning is done in collaboration with the Research Council, it may serve as a model for how other research groups could deal with the same problem.

4.1.2.2 The ITA Extragalactic astronomy program

An active cosmology/extragalactic program is carried out by two professors. It concentrates in several modern areas of extragalactic astronomy, especially lensed QSOs and “weighing” clusters of galaxies. The group is also focusing on building the required competence in data analysis for observational cosmology, especially for observing the diffuse cosmic microwave background (needed for working on ESA/Planck data) and is involved in the ongoing enhancement of focal plane instrumentation for the NOT.

The Planck involvement represents the highest-risk (but also highest possible payoff) new project within the extragalactic program; it has been given the highest priority for future extragalactic projects. Planck promises to address many of the most important aspects of observational cosmology. ITA’s role in Planck will be largely devoted to data analysis, including development of new data analysis and reduction techniques. As part of the effort to build up the necessary expertise, there is now one Ph.D. student working on data analysis at the Planck DPC in Garching. This may be subcritical preparation for such a high-visibility project.

Observations with the NOT represent the core of ongoing activities in this group, and will likely continue in this central role for the foreseeable future. For this reason, the future of NOT is a central issue for extragalactic research at ITA.

Assessment

The level of activity in extragalactic research at ITA is remarkably wide-ranging, and we suspect that -- given the small number of faculty members involved in this research area -- there is considerable danger of over-extension; it is clear to us that this part of ITA’s program needs more faculty. The publication record in this group is somewhat modest on average, thus while Lilje’s publication and citation records can be rated as good, Stabell’s is rated as good to fair. Our summary assessment is that if the danger of over-extension is ameliorated by the addition of at least one new faculty member whose productivity is similar to that of Lilje’s, then this research area is a promising area of expansion for ITA.

Recommendations

This is a subcritical program, and needs strengthening. We strongly support ITA’s already mentioned plans to transfer one position from the solar program to this one. As the extragalactic program grows, yet likely remaining relatively small, ITA needs to make sure to maintain focus and to be careful in determining the range of extragalactic research activities pursued at ITA.

4.1.2.3 The ITA Celestial mechanics program

Celestial mechanics at ITA follows very traditional lines. This group (Aksnes) produces the Almanac, whose sales are a significant source of support for the Institute. Present plans are to maintain this program at the same level as now. There are plans for involvement with the ESA Rosetta project, a cometary mission. Since the data for this mission will become available after the retirement of Aksnes, there is concern at the lack of specific plans for Rosetta involvement.

Assessment

The publication record in this group is poor. In terms of general activity level and quality of research, this group is rated as fair. The publication of the Almanac is an outreach activity that clearly provides a highly visible profile and useful funds for supporting ITA's research activities.

Recommendations

We concur with ITA's decision to largely phase out this research group as retirements occur. Certainly, it would be unwise to appoint a new faculty member in this area, given ITA's plans for the future in solar and extragalactic research. However, publication of the Almanac serves an important public outreach function for the Institute, and therefore ITA should actively plan to maintain its role in the publication of the Almanac with the support of non-faculty ITA staff members.

4.1.2.4 Overall assessment and recommendations

ITA is the leading astronomical institution in Norway and has managed to play a leading scientific role in solar physics. ITA has planned strategically for some time, and continues operating in this tradition. It closed the Oslo Solar Observatory when it no longer made scientific sense to run it; it closed the ITA mechanical workshop, and outsourced its activities, when it made economic sense; it is building up a Numerical Simulations group, at a time when it has become internationally recognised that simulations can productively form a "third road"; it focused on space research to take advantage of solar-related ESA missions. But there are also examples of poor or insufficient planning, like the involvement (or rather, non-involvement) in Norway's contribution to ESA's INTEGRAL mission (see UiB), and ITA's involvement with Rosetta.

The age distribution of ITA's faculty is such that a number of retirements will occur over the next decade. It is therefore important for ITA to carefully plan the renewal of its faculty. A specific example is an upcoming retirement in the Solar/Stellar group; we strongly support the planned transfer of this solar position to extragalactic astronomy. Such an appointment would be essential for effective involvement in Planck and a vigorous extragalactic research program.

The roles to be played by ITA in a number of observational/experimental programs are not well defined, and need to be resolved as soon as possible. For example, the future of NOT, and Norway's role in this project, should be clarified. Currently, NOT is Norway's sole means of access to state-of-the-art ground-based optical astronomical observations; in its absence, the Research Council of Norway will need to make alternative arrangements for access to comparable (or, better yet, superior) observational capabilities in the optical region. ITA has implicitly decided not to invest heavily in INTEGRAL; this is a decision that we concur with, given the scarcity of faculty and financial resources. Similarly, since it is unlikely that Aksnes upon his retirement will be replaced by another person working in this area, ITA's involvement with Rosetta is best left at a very modest role.

4.2 University of Bergen

4.2.1 Department of Physics

The Department of Physics is organised in four sections, Applied Physics and Technology, Subatomic Physics, Space Physics, and Theoretical and Computational Physics. The faculty staff consists (1999) of 19 professors and 16 associate professors. From 1982 on, when the research was almost exclusively of a basic nature, a comprehensive redirection of the activities has taken place with the result that today about half of the scientific staff is engaged in applied research and technological development.

4.2.1.1 Applied Physics and Technology section

The section of Applied Physics and Technology in the Department of Physics at the University of Bergen consists of six research groups with a staff of six professors, nine associate professors, and four adjunct professors. This amounts to almost half of the academic staff of the whole Department of Physics. The research and development in this section is of applied character and technologically oriented. A considerable part of it (microelectronics, industrial instrumentation) is done in close interaction and collaboration with either the CERN-related particle physics activity or the Astrophysics and Space-Physics groups in Bergen. The other groups work in hydroacoustics, reservoir physics, optics and laser physics, as well as in process safety and technology.

In the past five years, there were far more cand.scient. graduates (81) and dr.scient. graduates (21) in this section than in the other sections of the Department of Physics together (51 respectively 6). This is probably also a consequence of the good job opportunities for these graduates in applied physics, which follows at least partly from the close co-operation of practically all groups with industrial companies in Norway and abroad. In addition, the section has many close connections with the Christian Michelsen Research Lab. (CMR), which is owned to 50% by the University of Bergen.

<u>Hydroacoustics</u>

The group in hydroacoustics consists of professor Hobaek and associate professor M. Vestrheim. The activities are focused towards model experiments in underwater acoustics and applications of ultrasound. The research subjects include (i) non-linear acoustics/focused sound, which has many applications e.g. in medical diagnosis and therapy; (ii) environmental monitoring of e.g. global warming of the ocean water by acoustic tomography or of the thickness of the surface ice; (iii) transducer technology, which is of basic interest in ultrasound research and technology; (iv) gas measurements of e.g. temperature, density, flow in pipes etc.; (v) underwater acoustics e.g. for the determination of plankton stock by acoustic-echo methods. The group has many collaborations with industry and research institutes, including CMR, the Institute of Marine Research, the Nansen Environmental and Remote Sensing Centre, and Simrad AS. The publication record of both Hobaek and Vestrheim within the past five years is rated as fair.

<u>Industrial Instrumentation</u>

In the Industrial Instrumentation group, one professor (Hammer) and four associate professors (Fett, Johansen, Olsen, Tollefsen) work on a number of projects in specialised instrumentation for off-shore production of oil and natural gas, including flow meters for oil, gas, and water, for gamma-ray tomography to monitor air-pollution, as well as for medical or forest or aquaculture applications. The group has co-operative projects with a large number of industrial companies and research institutes, including CMR, ABB, Statoil, Integrated Detector Electronics, and others. The publication records within the most recent five years of professor Hammer and associate professor Johansen are rated as fair, those of associate professors Tollefsen, Olsen, and Fett as poor.

Microelectronics

The Microelectronics group includes two faculty members, associate professor Ullaland and associate professor Van Vo as well as one senior engineer (Olsen). Its activity is mainly focused on the design, simulation, and production of analogue and mixed analogue-digital VLSI systems, including electronics for space crafts and rockets as well as applications in industry and particle physics. The projects in recent years include electronics for ESA CLUSTER satellites, a low-noise CCD data acquisition system etc. Some of the research and developments are in co-operation with foreign research institutes. The activity of this group is good even though the publication record is poor.

Reservoir Physics

The research of the Reservoir Physics group is done in close co-operation with the Norwegian oil industry. The main objective is to study transport mechanisms in porous media both by experimental methods and by numerical simulations. The group has developed a nuclear imaging technique (NMR) for measuring saturation profiles and also parameters like porosity, pore-size distribution etc. The group includes two professors (Graue, Kolltveit) and associate professor Lien. The research is again done in close co-operation with the oil industry, which partly finances the research, as well as with several universities in the US, Great Britain, and France. This is a successful and useful research activity even though the publication records of two of the staff members (Kolltveit, Lien) within the past five years are only fair; professor Kolltveit, however, has also published two monographs. Professor Graue has published a sizeable number of papers and his publication activity is rated as good.

Optics and Laser Physics

The Optics and Laser Physics group is formed by professor Stamnes and associate professor Singstad. The research activity is mostly concerned with diffraction tomography, satellite remote sensing, optical methods for ocean-water and climate study applications. The research projects are carried out in close co-operation with a number of companies and foreign universities, including Texas A&M University, the University of Alaska Fairbanks, and the Royal Institute of Technology, Stockholm. The publication record of professor Stamnes is very good, with a number of papers in high-impact journals, while that of associate professor Singstad is poor.

Process Safety and Technology

The group on Process Safety and Technology is still a one-man activity started in 1996 with the appointment of professor Eckhoff. The research in the group, focused mainly towards the problem of dust and gas explosions, is done in close co-operation with CMR. It is planned to appoint an additional professor in the year 2000, whose field of research will be natural gas processing. The publication record of professor Eckhoff is good, and he has also published two monographs on safety matters in the process industry. The group plans to change its name in the near future to Process Technology & Instrumentation.

Assessment

The Applied Physics and Technology section within the Department of Physics is judged as a very strong and successful activity. The various groups work in a number of rather important technological fields, which are of current interest both for Norwegian industry and for fundamental physics-oriented research groups in the department. The research program attracts a relatively large number of students. This is probably related to the close co-operation of most of the research groups with industry and other applied research institutes in Norway and abroad.

Recommendations

The evaluation group agrees with the view of the Department of Physics that very little should be changed in the near future in this section. The staff positions that will become available within the next couple of years through retirements should be filled again with young researchers in order to strengthen the presently successful activities.

4.2.1.2 Subatomic Physics section

The group consists of eight professors, one adjunct professor, and one full time research associate. Five of the current members of the section have an age of sixty or more, which will soon provide an opportunity for restructuring this section and increasing the scientific viability.

<u>Experimental Particle Physics</u>

The experimental particle physics activity is divided into two subgroups. One subgroup (professors Olsen and Myklebost) is involved in the continuation of the analysis of the WA102 experiment. The main activity (professors Eigen, Frodesen, Lillestøl, and Stugu) is devoted to the DELPHI and ATLAS experiments at CERN, in close collaboration with the Oslo group, and the BABAR experiment at SLAC. Professor Lillestøl has a 50% unpaid leave contract and is heavily involved in outreach activities. In the DELPHI experiment, the group has contributed to the construction of two luminosity monitors (SAT and STIC) that have been instrumental for the precision measurement of the Z-boson line-shape. The DELPHI-activity is now concentrating on data analysis, while the ATLAS-activity is focused on the inner detector (ID). The group has contributed to the design and, in collaboration with Oslo and Uppsala, is responsible for constructing one layer of the silicon barrel. The BABAR activity includes participation in the running of the experiment and in the data analysis and involves one doctoral student as well as diploma students. The overall rating of the work is good.

<u>Experimental High-Energy Nuclear Physics</u>

The experimental high-energy nuclear physics program is done in close collaboration with the Oslo group. The group is working on the WA97/NA57 experiment at CERN and is committed to the construction of the ALICE detector at LHC. In addition the group will participate in the BRAHMS experiment at Brookhaven. The participation in ALICE includes the development of the front-end electronics for the photon detector (Klovning) and the development of the high-level trigger system (associate professor Röhrich). The contribution to the other experiments is mainly in the field of data analysis. The overall rating of the work is good.

Theoretical Particle Physics

The group has a single faculty member (Osland) whose interest is in understanding what can be learned from existing data and from data to be obtained in future experiments. He works on a diverse range of topics, including QED, QCD, non-minimal electroweak theory, supersymmetry, and neutrino oscillations. He collaborates with many groups internationally as well as with students, and has a good publication record.

Assessment

The experimental particle physics activity in ATLAS and BABAR has a good scientific profile, but is quite dispersed in relation to the size of the group. Moreover, the group has had very few doctoral students in the past five years.
A point of concern is the possible conflict between the common involvement of the Bergen and Oslo groups on the demanding ATLAS program and the diversification of the activities during the period of construction and installation of ATLAS when the CERN accelerators will be closed.

The program of the Experimental High-Energy Nuclear Physics group has a good scientific profile, but the group is understaffed in relation to its scientific program, particularly so due to the recent loss of professor Thorsteinsen (deceased). A point of concern is the possibility for this small group to carry through the ambitious program with strong involvement in two large experiments in the US and at CERN.

Recommendations

The number of people working in the ATLAS team should be increased by internal reshuffling when the activity on WA102 ends. The group should limit all alternative programs in order not to weaken its main commitment to the CERN program. The vacant position in high-energy nuclear physics should be refilled as soon as possible, preferably by hiring a dedicated young researcher on a tenure-track position. For the theory activity it is recommended to provide support for visitors to the group.

4.2.1.3 Space Physics section

The Space Physics section is formed by five staff members, one professor (Søraas) and four associate professors (Aarsnes, Bjordal, Brønstad, and Stadsnes). All group members are over 60 and two will retire within the next 2-5 years.

Since quite some time, the whole group is engaged in building space-born instrumentation (energetic particle and X-ray detectors) as one of the leading groups in Europe. The group is internationally well recognised for its competence and is co-operating with instrument teams on European (Viking, Cluster), US (CERES, Polar) and Japanese satellites (Geotail).

The data analysis efforts and the scientific output of the group cannot keep pace with its very good expertise in instrument building. Publication and citation records (considering papers cited during the past six years) range from good (Søraas) and fair (Stadsnes) to poor (Aarsnes, Bjordal, and Brønstad).

The group is also involved in building instrumentation for an astrophysical satellite (ESA's gamma-ray INTEGRAL mission). When this project was initiated, ITA had expressed interest to participate in the reduction and analysis of INTEGRAL data. What Norway's scientific involvement will be once INTEGRAL flies, however, is not clear at present. It is not obvious to us how this involvement will be structured and made effective, because the reduction and analysis of the INTEGRAL data will require a background in high-energy astrophysics, which is not available in Bergen. Since the interest of ITA in INTEGRAL has waned, Bergen is faced with a major quandary as to how the INTEGRAL data analysis will be carried out.

Assessment

This group excels in building instrumentation, but is weak on the data analysis side (a polarity quite often found in the space physics community). International and national co-operation is strong, but again mainly on the hardware side. Scientific productivity has recently picked up due to good doctoral students. The age structure poses a potential problem. The overall rating is very good to good. Better co-operation with the Plasma and Space Physics group and the ITA at UiO, especially after the start of the CLUSTER mission, is encouraged.

Recommendations

The group plays an important role in Norwegian space physics, because satellite-based space physics cannot survive without a strong instrument-building program. However, there is a clear deficiency in data analysis and thus doing physics with the data. There are two choices for remedy: (1) Better co-operation with the Plasma and Space Physics group at UiO and filling one or two of the positions that will become open during the next five years with space physicists that specialise in data analysis and interpretation; or (2) phase out space physics in Bergen, since all members of the group will retire during the next 10 years and move instrument-building to UiO. On the long run, choice (2) may have higher synergy effects.

The involvement in an astrophysical mission would make sense only if scientists at Bergen or at least other Norwegian universities can be identified, which are willing to devote themselves to analysis and interpretation of its data. There seems to be no interest in Bergen and only a superficial one at ITA in Oslo. Thus the effort is extremely subcritical and might be called a waste of financial and human resources. It should not be followed up.

4.2.1.4 Theory in Bergen

Work in theoretical physics at the University of Bergen is spread over two groups, the “Theoretical and Computational Physics section” and the ”Theoretical Particle Physics” group.

Theoretical and Computational Physics section

The work in this section is in atomic and subatomic physics. Within the latter there are two main areas of research, collisions between relativistic heavy ions and the physics of radioactive nuclear ion beams.

There are two current faculty members doing research in atomic physics (professor Kocbach and associate professor Hansen), as well as emeritus professor J. Hansteen, who built up atomic physics research in Bergen. Their interests have shifted in recent years to collisions between atoms in the presence of strong radiation fields produced by lasers, which is one of the current focuses of research in atomic physics internationally. The group publishes internationally at a good rate, with Hansen being more prominent in this respect than Kocbach. The group has the intention of taking up subjects in the theory of quantum information. Hansen is also studying clustering phenomena with scientists at Hydro Aluminium AS, Karmøy.

Work on collisions between relativistic heavy ions is devoted mainly to study the freeze-out following the collision between two heavy ions. This subject is of importance for understanding signals from current experiments at heavy-ion colliders now in operation and under construction. The faculty member (Csernai) has a very good publication record, and most of his work is in collaboration with scientists from outside Norway. He was also the leader in the initiative that led to the setting up of the "Bergen Computational Physics Laboratory" with funding from the EU.

The faculty member working on radioactive nuclear ion beams (Vaagen) has been the driving force in creating an international collaboration with participation of physicists from Russia, Great Britain, and the Nordic countries, the so-called RNBT collaboration. This subject is one of the major frontiers in research in contemporary nuclear physics, and will become increasingly important in the future when a number of new facilities for producing radioactive beams will come into use. The RNBT group has a high profile in the international physics community, and has been responsible for a number of the developments in the subject. The faculty member's publication record is rated as good. Most of the publications are written together with members of the RNBT group.

Assessment

Given the small size of the section, it is remarkably successful, largely as a result of extensive international collaboration. In atomic physics there is a lively activity in Bergen, and it appears that something like a group functions there in this subfield. This is demonstrated by the initiatives taken by the faculty to move into new areas, including studies of quantum computing and atomic clustering. In the other areas there is little scientific overlap between faculty members, and this remark includes the other theorist, P. Osland, who administratively is a member of the Section for Subatomic Physics. Without the support that a group offers, it is very difficult to create an active scientific environment.

The section attracts graduate students, especially from abroad (China, E. Europe). Many of them go on to graduate school at major international centres, and there are at present a number of doctoral students in theory.

Recommendations

To encourage the creation of a more active environment, measures should be taken to ensure that more of the work done by members of the faculty is carried out in Bergen, rather than at other centres. Among these could be the funding of temporary positions for visitors and postdocs.

Furthermore, the opportunities offered by the newly established "Bergen Computational Physics Laboratory" should be exploited for attracting talent not only in computational physics, but also in physics more generally.

4.2.1.5 Overall assessment and recommendations

The Department of Physics in Bergen has gone through an organised change from purely basic research to a structure with a mixture of basic and applied research and technological development. The department presented itself with a clear strategy to keep the fraction of basic research at its present level, which means that any further expansion of applied physics would not occur at the expense of basic research. The representatives of the department presented a long-term plan for phasing out the present activities in materials technology and process safety technology. The evaluation committee expresses concern about the relatively low number of physics graduates from this department, and strongly recommends a thorough analysis of this situation as well as the application of effective countermeasures.

The overall structure of the Department of Physics at the UiB, however, is very unusual in several respects:

(i) There is practically no basic physics based on in-house experimental activities.

(ii) The total lack of condensed-matter/ materials science is a weak point and poses a problem in particular with respect to the overall educational program in physics.

(iii) The activities in space physics are predominantly devoted to instrument building.

In order to change this rather unfavourable situation, which might well be one of the main reasons for the relatively low number of graduate students in physics at Bergen, the evaluation committee strongly recommends phasing out space physics at the UiB at the earliest possibility and to use the resources which become available by this to start up a group of newly appointed staff members with critical mass in a promising basic-physics oriented field that would complement the remaining existing research activities at the department (applied physics, subatomic physics, theoretical and computational physics). This new activity should be in the general field of condensed-matter/materials science; the committee recommends considering the science of nano-structured materials. It should be pointed out that the age distribution of the faculty members in the department, particularly in the Space Physics section, is highly favourable for such a restructuring of the department to be carried out in the very near future.

The phasing out of space physics at the UiB is a very reasonable step, since it will lead to a much-needed concentration of space physics in Norway to fewer sites. At present, there are activities in this field at three of the four major universities as well as in two additional laboratories. On the other hand, the recommended step will lead to a discontinuance of the instrument-building activities of the Bergen group, which is a loss for Norwegian space physics that should be compensated to some extent by restructuring the research and development in this field at the other remaining sites.

The Applied Physics and Technology section is very technologically oriented and has strong contacts with industry as well as with scientists in the group for Subatomic Physics and Space Physics. The committee finds this overall structure of the department as well as the activities of the Applied Physics section as a whole rather successful, but judges the total fraction of applied physics at this department to be at the upper limit. A point of concern, however, is the quite low publication output of the Applied Physics section as a whole within the past five years.

The Subatomic Physics section should seriously consider to focus its activities to the CERN-related research work in order to achieve a situation, where enough staff is involved, i.e. a critical mass is reached. A continuation of the close collaboration with the Oslo group is strongly recommended.

4.3 Norwegian University of Science and Technology

4.3.1 Department of Physics

The Department of Physics at the Norwegian University of Science and Technology (NTNU) consists of a faculty of 31 professors, 15 associate professors, and 8 adjunct professors. At present, there are 40 doctoral students at the department. The research of the department has recently been evaluated by a partly external committee, which led to a new structure with research activities in essentially three main areas: Condensed-Matter Physics and Optics, Biophysics, and General Physics. While the Condensed-Matter Physics section, with research efforts in materials physics, surface physics, condensed-matter theory, and applied optics, is rather coherent, the Biophysics section is more diverse, with three research groups working in medical technology, biopolymer physics, and biosystems. The third section, called General Physics, consists of four research groups with rather diverse interests: Astro-particle theory, electron/ion physics, didactic physics/school physics, and energy/environmental physics. This is partly a consequence of the fact that NTNU was created in 1996 by merging the two former universities in Trondheim, Technical University of Norway (NTH) and College of General Science (AVH).

4.3.1.1 Condensed-Matter Physics and Optics

The Section of Condensed-Matter Physics and Optics is divided into four research groups: Materials Physics, Surface Physics, Condensed-Matter Theory, and Applied Optics.

<u>Materials Physics</u>

The Materials Physics group includes six professors (Fossheim, Holmestad, Høier, Mo, Samuelsen, Tøtdal) and one adjunct professor (Lohne). At present there are nine doctoral students in this group. A major part of the research in materials physics is based on rather classical techniques and topics, like transmission electron microscopy and X-ray crystallography, but some of the researchers use also the neutron beams at Kjeller. Three professors (Holmestad, Høier, Tøtdal) and the adjunct professor (Lohne) make use of the available 300-kV TEM (Transmission Electron Microscope) for microscopy and to a lesser extent for spectroscopy, studying e.g. Al-based alloys and intermetallic compounds. Some of the research, with a good (Holmestad, Høier) to fair (Tøtdal) publication record within the past five years, has been done in collaboration with the Materials Physics group at SINTEF.

The activity in crystallography (Mo) is increasingly done in collaboration with researchers from the neutron facility at Kjeller and two staff members at Stavanger College, making use of the intense X-ray beam available at the Swiss-Norwegian beamline at ESRF. This activity has led to good results, as documented by publications, in the past five years.

There is also an activity in the field of structure and dynamics of flux lines and flux pinning in high-T_c superconductors (Fossheim), which has also led to good results in the recent past.

A further activity in materials physics is concerned with the structure of conducting polymers and organic semiconductors (Samuelsen) using X-ray diffraction and spectroscopic methods. This research, which is performed in collaboration with Electrochemistry and Organic-Chemistry groups at NTNU, and seems to be one of the few interdisciplinary research programs, is also making use of the X-ray beams at ESRF, and has led to good results in the past five years. Professor Samuelsen has also served as a member of the Science Advisory Committee of the ESRF.

Surface Physics

The activities in surface physics (Hunderi, Raaen, Borg, Bremer) include optical studies of surfaces and interfaces (Hunderi), photoelectron spectroscopy and scanning-tunnelling microscopy (STM) of surfaces, adsorbates (Borg), and thin films, including thin films of lanthanide metals prepared in situ on substrates (Raaen). As a whole, the surface physics activity is judged as good (Hunderi, Raaen, Borg) to fair (Bremer), even though it does not quite keep up with the international progress in that field. However, this is an activity that should be strengthened in the future.

Condensed-Matter Theory

The Condensed-Matter Theory group, with seven professors (Hansen, Hauge, Hemmer, Høye, Myrheim, Olaussen and Sudbø), is the major theoretical group in the Department of Physics at NTNU. The present group structure in theoretical physics at NTNU has resulted from the above-mentioned merging of the two previous universities in Trondheim. While the main focus of research in the Theoretical Physics group at NTH, now forming the Condensed-Matter Theory group, was in statistical mechanics, the group at AVH, now forming the Astro-Particle Physics group, worked in elementary-particle physics and to a lesser extent in astrophysics. The two groups were located at different campuses, and they had rather little contact with each other. In addition, the theoretical group at NTH was located in a separate building away from the experimental groups. The relocation of the whole physics department into the new natural science building on the main campus of the university will offer new opportunities for physics at NTNU.

Originally the main activity in the group was statistical mechanics, but this was extended to include tunnelling phenomena, semiconductor heterostructures, and mesoscopic systems in the mid 1980's, and field theory, the quantum Hall effect, the theory of complex systems, and high temperature superconductivity more recently. At present Hansen and Sudbø are very active in research, have excellent publication records, and attract students. Also Hauge, Hemmer, and Høye have very good publication records, and Myrheim and Olaussen have good ones. There are real collaborations between members of the group, which has demonstrated the ability to renew itself.

Applied Optics

The fourth research group, consisting of three professors (Løkberg, Pedersen, Valera) is working in applied optics, which comprises optical metrology (Løkberg), optical holography (Pedersen), and fibre-optics interferometry (Valera). The research results in these essentially classical fields of optics are rated as good (Løkberg) to fair (Pedersen). Professor Valera's publication record has been poor in the last five years.

Assessment

The Condensed Matter Theory group at NTNU is a very positive element on the Norwegian physics scene. It represents the most vital environment for theoretical physics in Norway, and has demonstrated its ability to produce work of high quality, to change scientific direction, and to welcome younger scientists working in new areas. The group is strong in a broad range of topics in condensed-matter physics, it attracts students, and its overall output is very good. One of the challenges for this group will be to maintain its good traditions upon the move to the new building. This move, however, will also provide opportunities for strengthening the group still further by close collaboration with theorists now in the Astro-Particle Physics group in General Physics section. Because of its broad interests and its good record for rejuvenation, it is a natural environment for new initiatives in other areas of theory.

A major part of the research in materials physics is based on rather classical techniques and topics, like transmission electron microscopy and X-ray crystallography, but some of the researchers use also the neutron beams at Kjeller and the intense X-ray beams of the Swiss-Norwegian beam-line at ESRF. The materials science research is rated from good to fair. The surface physics activity is judged as good and has the potential for further improvements in the near future. The research in applied optics is essentially in classical fields and is rated as good to fair. As a whole, the experimental research activities in the section Condensed-Matter Physics and Optics do not reach the same quality standards as the theoretical activities in the Condensed-Matter Theory group.

Recommendations

The evaluation committee recommends using the existence of a strong Condensed-Matter Theory group as a challenge to also strengthen the experimental activities in this section. This provides a chance of creating a very strong section Condensed-Matter Physics and Optics as a whole. In this respect the surface physics activity should be strengthened by making funds available for the acquisition of a state-of-the-art photoemission spectrometer with an intense laboratory XUV-source. New activities should be started in the field of condensed-matter physics, to strengthen this field, particularly in the area of highly correlated materials (3d- and 4f systems), including magnetism. In general, a closer collaboration between theory and experiment should be aimed for.

Within the next few years there will be a number of retirements in the Condensed-Matter Theory group. The highest priority should be given to attracting to the positions that will become open, young scientists of great ability, who will be able to continue the excellent traditions of the group.

The most active theorists in the Astro-Particle Theory group, Skagerstam and Østgaard, have research interests that complement those of the Condensed-Matter Theory group. These overlaps should be exploited, with the aim of strengthening the theory group at NTNU.

4.3.1.2 Biophysics

The Biophysics section is a consequence of the 1998 evaluation of physics at NTNU, when about 20% of the total activity in physics was directed into the field of biophysics. The major reasons to follow this direction were the expected co-operation between physics, molecular biology, and medicine in the coming decade as well as the significant activity in medicine and molecular biology at NTNU. The present research in biophysics is divided into the following fields: Medical technology (professor Lindmo, associate professor Davies), Biopolymer physics (professor Elgsæter, professor Stokke, associate professor Mikkelsen), and Biosystems (professor Johnsson, professor Melø, professor Naqvi, and professor Valberg). Only the Biosystems group has three faculty members who will retire within the next decade.

<u>Medical technology</u>

Research in medical technology is focused on medical diagnostics and therapy, largely based on the development of methods related to flow cytometry and optical tomography. Projects concern the transport of drugs to tumours and the imaging of tissue. Lindmo's work is largely associated with the cytometry and tomography projects, including some medical-technological innovations. The research seems to have solid links with the medical faculty. Lindmo has been reasonably productive during the past five years and his work, rated as good, has some international visibility.

The work of Davies is strongly cancer-research related, with a low physics content and a relatively low productivity. The work has been published in international journals, but has only limited international visibility, and is rated good to fair.

<u>Biopolymer physics</u>

The second field, biopolymer physics, is focused on studying the hydrodynamic and electrical properties of biomolecules and biomolecular assemblies. The group, headed by Elgsæter, develops and applies well-established electro-optical methods supplemented by commercially available techniques (e.g. EM, AFM, rheology). The research can be considered as mainstream biophysics. The productivity of Elgsæter is very good (about five papers/year), and he publishes in good international journals. His papers are reasonably well cited. Mikkelsen operates closely to Elgsæter, with a focus on the electro-optical part of the project. He publishes regularly and his scientific output is rated as good. Stokke's independent research is more in the direction of soft condensed matter (bio-matter). He publishes actively in international journals and his work, rated as good to very good, is reasonably well cited. However, there are no top papers or papers in top journals.

<u>Biosystems</u>

The research in the biosystems field is focused on biophysical aspects of plants (Naqvi, Melø, Johnsson). A further research line concerns the visual system (Valberg).

The major part of the work of Naqvi is related to the photosynthetic light-harvesting process in plants and the role of carotenoids. The research is reasonably productive (2-3 papers/year), and the results are published in international journals.
Melø works very closely to Naqvi, but has an independent activity studying the oxidation of fatty acids. He publishes regularly in international journals.
The published work of both Naqvi and Melø, however, has a relatively low visibility; it is rated as good to fair.

Johnsson's most recent research addresses the gravity perception and balance system of plants and includes a space-oriented activity. Earlier work concerned the water transport in plants and biological clocks (e.g. circadian rhythms). The work is strongly biologically oriented and is on the periphery of international biophysics. Johnsson publishes regularly in international journals, however, his work, rated fair, has a relatively low visibility.

The fourth faculty member in this group, Valberg, studies a variety of aspects of the visual system. One topic is parallel processing within the visual system. Low vision is studied in relation to the rehabilitation of people with age-related macular degeneration. The group studies also the phenomenon of colour vision and perception in relation to neurophysiology. The work is mainstream vision research. In the last five years, Valberg's work has shown a low productivity (only two papers published in international journals, one in press, three accepted); his earlier work, however, has been widely recognised; the overall rating is good.

Assessment

To summarise the assessments, there is an established, coherent, productive, and visible program in biopolymer research. The research in the Biosystems group, on the other hand, is much scattered and for a large part of relatively low impact. In biomedical technology/ medical physics (Lindmo, Valberg), a research area with active contacts to the medical research community has been established.

Recommendations

The next decade will show the integration of physics, biochemistry, and molecular biology. Based on the existing coherent efforts at NTNU in biomolecular assemblies, we advice to develop a new experimental activity in biomaterials/soft condensed matter. The initiative exploits the expertise of the Condensed-Matter Theory group at NTNU. The study of biomaterials/soft condensed matter will in part require new in-house experimental facilities and in part be based on using the neutron facility at Kjeller. The participation of the staff currently active in the Biosystems group in this new initiative must be critically investigated.

The group on Medical Physics/Technology should be further developed. This group will include the vision research at NTNU and must build on other existing strong biomedical-technological activity at NTNU. In such a new group the technological aspects should be strengthened at the expense of the cancer/biology related research.

A new facility employing femtosecond laser spectroscopy is recommended to be initiated in experimental condensed matter physics (see 4.3.1.4). This facility will connect the research on condensed and biomatter, open up new activities for biomaterials research and allow the study of elementary events in photobiology.

4.3.1.3 General Physics

In the section of General Physics, four research groups are working in a rather incoherent way: One group with four professors (Kolbenstvedt, Mork, Skagerstam, Østgaard) and two associate professors (Waldenstrøm, Øverbø) works on field theory, quantum optics, astrophysics, and subatomic physics. A second group of two professors (Sigmond, Skullerud) and two associate professors (Løvaas, Stefansson) in electron/ion physics. Then a group of two associate professors (Kind, Stegavik) in the field of didactic physics/school physics, and finally a group with one professor (Falnes), four associate professors (Kjeldstad, Kringlebotn, Løvseth, Strand) in the field of energy/environmental physics. As stated above, this rather incoherent "General Physics" group was historically formed by the merging of the physics departments at NTH and AVH.

Electron/Ion Physics

The scientific output of the Electron/Ion Physics group in the past five years has been fair (Sigmond, Skullerud) to poor (Løvaas, Stefanson). This type of research should not be further pursued when the positions become available through retirement.

Didactic-Physics/School Physics

The Didactic-Physics/School Physics group is formed by two associate professors (Kind, Stegavik). There have been no scientific publications from this group in the past five years. The committee has not obtained material to judge the necessity and content of this activity, but is convinced that a maximum of one faculty position should be devoted to this activity in the future.

Energy/Environmental Physics

The Energy/Environmental Physics group, which consists of one professor (Falnes) and four associate professors (Kjeldstad, Kringlebotn, Løvseth, Strand), has also had a rather poor publication record within the last five years, with the activities in wave-energy research (Falnes) and wind-energy research (Løvseth) being rated as fair, while the other activities have led to poor publication results. It is recommended that the continuation of this research direction be critically considered when positions become available through retirement.

Astro-Particle Theory

This group originated as the Theoretical Physics group at AVH before this college was merged with NTH. For many years it was led by professor Haakon Olsen who maintained a vital activity in particle physics. The title of this group is a misnomer, since very little of its current research is in what is generally referred to as astro-particle physics, the application of elementary particle physics to problems in astrophysics and cosmology. The group has four professors (Kolbenstvedt, Mork, Skagerstam, Østgaard) and two associate professors (Waldenstrøm, Øverbø).

Only two of the professors, Østgaard and Skagerstam, are active as far as publishing is concerned. Skagerstam works on quantum field theory and its applications to a variety of topics, including quantum optics. Østgaard works on many-body theory, on neutron stars, and on accretion onto black holes, and he is the only faculty member working on topics in astrophysics. The NTNU program in astrophysical research is therefore much less than might appear from the name of the research group, and really consists of the work of one faculty member. This program thus probably suffices to give undergraduates a taste of what astronomy and astrophysics are about, but it cannot be regarded as a critical mass for a graduate research program.

Skagerstam is in the process of moving into an area new for him, that of quantum optics. He is successful in attracting good students, and has good contacts to major research centres outside Norway. Østgaard also attracts students and both faculty members have good publication records. Overall the level of these faculty members is good.

Assessment

The work of the various members of the General Physics section is of quite different quality, and the inhomogeneous structure does not stimulate scientific collaboration between members of this section. With the exception of two theorists in the Astro-Particle Theory group, the scientific output of all the faculty members in this section has been fair to poor within the past five years.

Recommendations

In view of the extreme scientific diversity of the various groups in the General Physics section, its poor scientific output as a whole, and the fact that a number of retirements are imminent, the evaluation committee strongly recommends to dissolve this section by phasing out some of the research activities (electron/ion physics) or integrating others into successful research groups in other sections of the Department of Physics (Astro-Particle Theory group). Upon retirement of one faculty member in the Didactic-Physics/School-Physics group, this position should not be refilled in this discipline. When retirements occur within the Energy/Environmental Physics group, the whole research program in this field should be critically reconsidered.

4.3.1.4 Overall assessment and recommendations

The evaluation committee urges the department to use the present unique opportunity (new building, many imminent retirements, special new-building funds) to restructure some parts of its scientific research program by phasing out obsolete and/or unsuccessful activities, with the aim of strengthening the successful main research areas of the department (condensed-matter physics and optics, biological physics). This includes starting of new activities in those areas by hiring young and promising new faculty members recruited after an international search. These new activities should be at the forefront of present-day research and should also promise synergy effects through the possibility of close co-operation with existing successful activities in the department or on an interdisciplinary level within NTNU.

To underline first the recommendation for biological physics, it is appropriate to state that already the next decade may show the integration of physics, biochemistry, and molecular biology. Based on the existing coherent efforts at NTNU in biomolecular assemblies, we advise developing a new experimental activity in biomaterials/soft-condensed matter. This activity should be partially based on new in-house instrumentation and partially on exploiting the neutron facility at Kjeller. In addition the committee proposes to further develop the group on Medical Physics/Medical Technology. This group should include the vision research at NTNU. In such a new group the technological aspects should be strengthened at the expense of the cancer/biology-related research activities. The participation of the staff currently active in the Biosystems group in both initiatives should be critically investigated.

In the Condensed-Matter Physics and Optics section, the strong Condensed-Matter Theory group should be further strengthened by filling upcoming vacancies in this group without much delay with promising and young internationally recruited faculty members from outside and by integrating at least the two scientifically productive members of the Astro-Particle Theory group to further widen the scientific spectrum of the theory group. The experimental Condensed-Matter Physics and Optics section should also be strengthened by international recruitment of faculty members. The new staff should start a new research field that fits well into the existing activities, and by strongly improving the interaction and co-operation between experiment and theory. An important aspect is also the improvement of the experimental facilities available to this group, in particular the availability of sufficient funds for purchasing a state-of-the-art photoelectron spectrometer. In addition, access of this group to the XUV and soft-X-ray synchrotron-radiation facility MAXLAB in Lund, Sweden, is considered very recommendable.

In addition, the spectrum of experimental techniques available to this section should be expanded, in particular by starting a new field of research in non-linear optics and femtosecond laser spectroscopy. This would open up completely new opportunities for the department in areas like materials research, surface science, magnetism, optics, and also biological physics. Such a new experimental activity should be complemented by directing also theoretical efforts to quantum optics.

The restructuring of parts of the scientific research in the department is possible through the proposed dissolution of the General-Physics section. Within the next five years, 9 faculty positions will become vacant through retirements in the Electron-Ion Physics (4), Didactic-Physics/School-Physics (1), and Astro-Particle Theory (4) groups, which should all be transferred to the new activities in the department. A recommendation for the future of the Energy/Environmental Physics group cannot be given by the evaluation committee at the present time due to lack of information. The continuation of this activity should be seriously considered as soon as faculty positions become vacant through retirement.

4.4 University of Tromsø

4.4.1 Department of Physics

The Department of Physics at the University of Tromsø (UiT) is part of the Faculty of Science. The faculty of the Physics Department of the University of Tromsø comprises eight professors, ten associate professors, and four adjunct professors. In addition, there are at present ten doctoral students working in the department as well as two post-doctors. Formally the Department of Physics has 24 faculty positions, but only 18 of those are occupied due to a strategic decision on one hand (a larger budget for research) and budget limitations on the other hand. This rather small faculty of 18 staff members is dividing its research efforts into six groups working in the following research areas: Cosmic Geophysics (four faculty), Plasma Physics (three faculty), Applied Physics (seven faculty), Molecular Physics (one faculty), Dusty Plasmas (one faculty) and Astrophysics (one faculty). The initiative to create a relatively large activity in applied physics was taken in the beginning of the 90's to make Tromsø more attractive to students. This decision has led to a new teaching program, the construction of new student training facilities and has, as such, been a major activity for the professors in that particular section.

4.4.1.1 Cosmic Geophysics

The Cosmic Geophysics group is the internationally most visible research activity at UiT. The Cosmic Geophysics group is formed by four faculty, two professors (Bjørnå and Brekke) and two associate professors (La Hoz and Løvhaug) plus an open professor position. Two more scientists (Hall and Hansen) from the UiT Observatory division closely co-operate with this group although formally not belonging to the Department of Physics.

The activity of the whole group is centred around the large international EISCAT project and the group works on the whole breadth of auroral plasma physics. The group is internationally well recognised and most of its members have a very good to good publication and citation record during the past six years, with two of its members (Brekke and La Hoz) ranking among the four most-cited space physicists in Norway, but La Hoz's recent publication record is poor. Løvhaug's rating is good, and Bjørnå's records rate fair. The associated scientists rate good to fair (Hansen) and good (Hall).

Assessment

The strength of this group lies in the strong focus on EISCAT-related work. International co-operation, in particular with Japanese scientists, further enhances this synergy effect. The overall rating is very good. The apparent lack of co-operation with the rest of the department is viewed as a weak point.

Recommendations

Better co-operation with the other space physics groups in Norway after the start of the CLUSTER-II mission is encouraged and enhanced co-operation with UNIS would provide another promising opportunity.

4.4.1.2 Plasma Physics

The Plasma Physics group does laboratory plasma physics with emphasis on transport phenomena. It is formed by two faculty positions, one professor, Rypdal, and one associate professor, Frederiksen. The former leader of the Plasma Physics group (Armstrong) has recently retired.

The group's activity was centred around a small plasma device (Blaamann). Publication rates are very good (Rypdal) to poor (Fredriksen) with citation rates ranging from very good (Rypdal; but mainly for pure theoretical physics work and not necessarily in top international journals) to poor (Fredriksen) during the past six years. Hence, scientific output from the plasma device can be rated as fair. The work now seems to shift to a smaller device and more applied physics activities (production of thin films in integrated optical circuits) using that device. There is no co-operation with the other two plasma physics-related groups (Cosmic Geophysics and Dusty Plasmas).

Assessment

The work of this group does not meet international standards.

Recommendation

The committee advises to discontinue the work related to Blaamann. The recent retirement of Armstrong gives the opportunity to discontinue laboratory plasma physics at UiT. A new activity in plasma physics should not be considered, since it is not apparent how such a new line of work would lead to success. The activity of the current staff of the Plasma Physics group must be reconsidered in the light of the proposed new structure of the Department of Physics at UiT, including the new group of Atmospheric and Molecular Physics (see 4.4.1.6).

4.4.1.3 Applied Physics

The Applied Physics group has recently changed its name to "Communications & Microelectronics", with the aim to attract more students in the field of applied physics in this way. The group currently consists of one professor (van Rheenen) and six associate professors (Chen, Eltoft, Hanssen, Hellesø, Jacobsen, Melandsø), who work in both hardware- and software-dominated fields related to communication and microelectronics. This is a technologically oriented program where the students study for an engineering degree "sivilingeniør". Between 1994 and 1999 the UiT has invested 3.5 MNOK in the building up of laboratory facilities for this group. In the microelectronics section four of the staff members work in hardware-oriented fields: Jacobsen (cancer therapy by hyperthermia using microwaves), Hellesø (integrated optics), Chen (noise in semiconductor devices), van Rheenen (electronics). Only Chen and Van Rheenen have a collaborative activity. The other three faculty members in the communication section have activities in theoretical or software-oriented fields: Eltoft (neural networks), Hanssen (digital signal processing), Melandsø (signal processing). At least two of these researchers have had to drastically change their previous research fields, in which their publication records were good (Melandsø) or fair (Hanssen). Melandsø from theoretical studies of dusty plasmas to signal processing and Hanssen from theoretical plasma physics to digital signal processing. The scientific output of the other staff members of this group (Chen, Eltoft, van Rheenen, Hellesø, Jacobsen) has been fair.

Assessment

This Applied Physics group, with its rather incoherent research profile, seems very isolated at the UiT, in particular due to the lack of engineering departments at this university. This must be a great disadvantage for the students, who cannot be sent to basic lectures in electrical engineering at UiT. In addition, the research subjects of the seven staff members as a whole do not add up in such a way to guarantee a broad enough and competitive teaching and research-training program for the students. Also the activities on neural networks and on hypothermia seem to be isolated, with no interdisciplinary research with other individuals or groups in biology, computer science or the medical sciences going on.

Recommendations

Part of the Applied Physics group (Hanssen, Melandsø) should focus their activities to the proposed new initiative in atmospheric physics at UiT (see 4.4.1.6).

A critical analysis should be made of the on-campus activities in bio-medical technology, for instance associated to the University hospital in Tromsø on the basis of which a strategic plan is formulated. Part of the activities in the Applied Physics group should be directed to such a campus-based activity.

4.4.1.4 Astrophysics

The astrophysics research at UiT is centred around two professors, Havnes and Solheim. Havnes' group involves a large number of activities, often related to astrophysical (planetary) dust studies. Much of the ongoing work is focused on the terrestrial (upper atmosphere) domain. The publication record shows substantial international collaboration. The work covers both theory and experiments (most prominently, a new suborbital rocket program), and includes involvement in the excellent observational programs carried out at Svalbard. Havnes' publication and citation records are very good.

Solheim's work is largely concerned with (ground and space-based) observations of binary systems involving white dwarfs, as well as modelling of these observations; and involves wide-ranging collaborations in optical astronomy. Solheim is one of the few Norwegian users of the NOT and of the Hubble Space Telescope; and is a participant in the "Whole Earth Telescope"; an effort by the international astronomical community for ground-based monitoring of variable optical sources with minimal data gaps. Solheim is a very active scientist with a good publication record. However, while involvement of undergraduate students is reasonably strong, the production of students at the doctoral level has been low. The research is rated as good.

Assessment

Tromsø's astronomy program is probably adequate for undergraduate teaching of astronomy and astrophysics, but is subcritical as a graduate program in this discipline; nevertheless, the activity level at Tromsø is remarkable, given that only two faculty members drive the entire research effort in this area. In Havnes, the University of Tromsø has one of the leading astrophysically-oriented scientists in Norway, he is also among the best scientists at the Department of Physics at Tromsø. Solheim is also quite productive; his recognition places him more among the average level of Norwegian astrophysicists.

Recommendation

The access of Havnes as well as Solheim to the resources at Tromsø appears to be limited. The committee urges the Department of Physics to assign an adequate support to Havnes' research programs. After the retirement of Solheim the committee advises keeping an undergraduate teaching program in astronomy.

4.4.1.5 Theoretical Molecular Physics

There is one theoretical molecular physicist, Røeggen. In the past his main interest has been in determining interatomic interactions, but he is currently directing his research towards a new method for determining electronic structure for molecules and solids. He has a good publication record, and much of his work is done in collaboration with students and/or with scientists at other centres. With respect to contacts to the other faculty members in the physics department, he appears rather isolated, both in terms of his area of research, and geographically, because he works at the main campus of the university, which is far from the physics department.

Assessment

The work on molecular quantum physics is good, and the broadening of the research program to treat more general problems is to be encouraged.

Recommendation

At least one theorist working in microscopic aspects of physics is essential in any physics department, so in planning for the future this should be taken into account. It is desirable that the person has interests in common with other members of the department.

4.4.1.6 Overall assessment and recommendations

There are some activities of good or very good quality like cosmic geophysics, astrophysics, and molecular quantum physics. The plasma physics activity is of poor quality. The activities in applied physics lack focus and should be restructured accordingly.

The committee proposes setting up a group in atmospheric physics in the Department of Physics at the University of Tromsø. This is meant to give support to the activity of professor Havnes, to integrate the activities in molecular physics (Røeggen), and to provide a scientific base for part of the activities in applied physics (Hanssen, Melandsø). The committee further advises formulating a strategic plan for such a group, in which a new in-house activity in the area of molecular physics related to physical processes in the atmosphere is explicitly considered.

The committee advises discontinuing the research in experimental plasma physics at UiT. The activities of the faculty currently operative in this program should be redirected in the light of the new initiative in atmospheric physics. The committee also advises strengthening theoretical physics.

A critical analysis should be made of the on-campus activities in bio-medical technology, for instance associated with the University Hospital in Tromsø on the basis of which a strategic plan should be formulated. Part of the activities in the Applied Physics group should be directed to such a campus-based activity.

Cosmic geophysics is the most visible activity in the Department of Physics and should in principle be kept at its present strength.

4.5 Agricultural University of Norway

4.5.1 Department of Agricultural Engineering, Physics section,

Physics is one of four sections at the Department of Agricultural Engineering at the Agricultural University of Norway (AUN). The Physics Department has approximately doubled in size since 1993 (10 faculty and 1 temp. faculty in 2000) when it was recognised that physics was at the basis of training programs in engineering, biotechnology etc. Following the appointment of four new faculty (two in 1994, two in 1996) an educational program in physics was actively developed with the result that elementary courses in physics are now taken by about 20% of all students at AUN. Also a cand.scient. program in Environmental Physics was established that attracts an increasing number of students. Student training facilities have been set up successfully.

The research in physics is divided into five research lines: Agricultural Meteorology, Bioenergy, Biophysics, Condensed Matter and Materials Research (Agrophysics), and Theoretical Fluid Dynamics.

4.5.1.1 Agricultural Meteorology

(Professor Thue-Hansen, associate professor A. Grimnes) The research is performed in an experimental field station, equipped with instruments to measure the energy, the physical state of the soil and the internal boundary layers of the atmosphere. In addition the group accumulates weather information (since 1874) and is involved in UV-data collection. There are no publications in international journals since 1994. It is not obvious to the committee how the current research activities can lead to an interesting physics research effort. Ranking of both faculty members, based on publication record, is poor. We note that Dr. Grimnes has played a leading role in upgrading the physics teaching program at AUN.

4.5.1.2 Bioenergy

(Professor Heyerdahl) The major current activity concerns the design of fuel ovens to use biomass (and other waste products) in a competitive manner. A bioenergy research laboratory has been established with the support of Norsk Hydro ASA. There are no publications in international journals since 1994. The company Organic Power commercialises some of the findings of this group.

4.5.1.3 Biophysics

(Professor Einevoll, associate professor Futsaether, associate professor Oxaal and associate professor Pedersen (temporary)) Two areas of research activity exist: biological neural networks and plant biophysics. The activity on biological neural networks (Einevoll) is theoretical and aims at understanding signal processing in the visual part of the thalamus in terms of a biologically relevant model. Einevoll has successfully published in solid state physics and this work is internationally recognised. So far no publications have appeared on the current subject (one is in press).

Research in plant biophysics focuses on the physics of water transport and regulation in plants, in particular in the root system (Oxaal) and on morphological changes in roots in response to certain pathogens using MRI and other microscopic techniques (Futsaether). Oxaal has published in high profile journals, largely in collaboration with Feder (UiO). This earlier work has some international visibility. No publications of the work at AUN have appeared so far. Futsaether has a few publications from earlier work, no papers about present research activities have appeared so far.

4.5.1.4 Condensed Matter and Materials Research (Agrophysics)

(Associate professor Andersen, associate professor Berre, associate professor Oxaal) Research was directed to study the granular properties of soil (Berre) and the transport of water in porous media (Oxaal). So far no publications in international journals in these areas have appeared. Berre has published a few papers in the end of the 80's /beginning 90's that did not receive much attention. Publication records of professors Berre and Oxaal have been poor within the past five years.

4.5.1.5 Theoretical Fluid Dynamics

(Professor Tyvand) Research topics include various aspects of fluid mechanics: porous flow, buoyancy-driven convection, impulse free-surface flows and water waves and laminar viscous flows. Tyvand publishes regularly with a rate that can be described as fair.

4.5.1.6 Overall assessment and recommendations

The department has successfully gone through a major expansion from four to nine faculty positions between 1993 and 2000. Through strategic planning the department was able to attract promising young physicists.

An educational program in basic physics was established that attracts a significant fraction of the students at AUN. A cand.scient. program in Environmental Physics was implemented. These programs are important for the spectrum of physics offered at Norwegian universities. However, the various research activities are scattered among the groups and a coherent research program still has to emerge.

In order to achieve this the research in the Physics Department should be reorganised in two sections: (1) Applied Agricultural Physics comprising the groups of Agricultural Meteorology and Bioenergy as well as associate professors Berre and Andersen and (2) Biological Physics/Physics of Complex Systems comprising the Biophysics and Fluid Mechanics groups together with associate professor Oxaal.

The Biological Physics/Physics of Complex Systems section, in collaboration with existing strong research activities at AUN (biotechnology), is advised to develop a strategic plan in an area of scientific interest to all participants that can be proposed for funding at the the Research Council of Norway. CEREBAND could be the nucleus of such a proposal. This may require the redirection of the research activities of some of the recently appointed faculty members.

4.6 University Courses on Svalbard

4.6.1 Department of Geophysics, Middle and Upper Atmosphere groups

University Courses on Svalbard (UNIS) was established only 7 years ago. Its main responsibilities are teaching and research in Arctic-related fields. It has four scientific departments: Biology, Geology, Geophysics, and Technology.

The two physics groups within the Department of Geophysics deal with atmospheric studies and space plasma physics and have each one temporary associate professor position (Sigernes and Moen). The Atmospheric group is doing spectral UV measurements (mainly ozone), while the Space Plasma Physics group deals with optical monitoring of the cusp aurora and associated solar-terrestrial coupling processes.

Sigernes did his Ph.D. thesis in space physics and has changed to atmospheric physics only recently. He is instrument-oriented (and good at that), yet has a very good publication and citation record for his young age. Moen is also quite young and has an excellent publication and citation record for his age. He is already internationally recognised and has recently accepted a professorship at UiO, where he will surely strengthen the group.

Assessment

The UNIS concept is unique in that it gives young scientists the opportunity for independent research. It exposes them to an international community of scientists (doing their research up there) and provides the chance for co-operating with them. Both have accepted these opportunities and reached very good (Sigernes) and excellent (Moen) results.

Recommendation

The physics part of UNIS is clearly one of the bright spots in the landscape of physics in Norway. It can also serve as an excellent and very promising example for an innovative approach to postdoctoral qualification on an international level. It might serve Norwegian atmospheric and space physics well to double the number of positions.

4.7 Stavanger University College

4.7.1 Institute for Mathematics and Natural Sciences, Physics group,

The Physics group at Stavanger University College is part of the Institute for Mathematics and Natural Sciences in the Faculty of Technology and Natural Sciences. It consists of two subgroups, a General Theoretical Physics group with three professors (Amundsen, Finjord, Knutsen), two associate professors (Almaas, Hellesøe), and one adjunct associate professor (Bjarne Aas), plus a Materials Science group with presently just one associate professor (Thorkildsen).

4.7.1.1 Materials Science

The activities in Materials Science at Stavanger University College are limited by the minimal size of this group, with presently just one associate professor (Thorkildsen), who seems to co-operate with his former dr. ing. graduate student, Larsen, now an associate professor at the Institute for Mechanical Engineering and Materials Technology. The two researchers concentrate their research activities on X-ray crystallography, specifically multiple-beam X-ray diffraction effects in finite crystals, by making use of synchrotron radiation at the Swiss-Norwegian beam-line at the ESRF. There is also some equipment for X-ray diffraction at Stavanger College as well as two scanning electron microscopes (SEM) and one transmission electron microscope (TEM). These on-site instruments are mostly used for teaching, however. The scientific output of the synchrotron radiation related work in materials science is rated as good, taking the circumstances into account.

Assessment and recommendations

The focusing of the experimental work to diffraction, particularly by using synchrotron radiation, seems to be appropriate and should be intensified e.g. by involving a dr. ing. student into this work. Complementary research with neutrons at Kjeller would be helpful. The evaluation committee strongly recommends that the presently open position of a professor in the Physics group is filled by an experimentalist working in materials science and making use of the opportunities with neutrons, synchrotron radiation and the electron microscopes.

4.7.1.2 Theory

The Theory group at Stavanger University College consists of five faculty members, three professors (Amundsen, Finjord, Knutsen) and two associate professors (Almaas, Hellesøe). There is no program in physics at the College, and their main task is to teach courses in physics to students in other e.g. petroleum-related programs. There appears to be little overlap between their research interests, which are broad: one works on astrophysics, another on atomic physics, and a third on petroleum engineering and the theory of complex systems, while the interests of the two other faculty members are not specified in the information supplied. Amundsen has published many articles, and he has a good citation record. However, probably due to his decanal duties, his current publication rate is only fair. Knutsen publishes at a steady rate, but mainly articles addressed to a general readership, and Finjord has published two articles in professional journals during the review period. For the group as a whole, the rating for the research currently being done is fair to poor.

With a group having as diverse interests as those of the present faculty, and without an active physics environment it is very difficult to have a significant activity in basic research in theoretical physics. Very special measures are necessary if a research program in theoretical physics is to be viable there.

Assessment and recommendations

The level of the present research effort in theory does not meet the standards required for a graduate program in physics. In making appointments in the future, emphasis should be given to choosing people whose research interests overlap to a greater degree. To reduce the scientific isolation, arrangements should be made to enable faculty members from Stavanger to have regular contact with other major centres of research.

4.7.1.3 Overall assessment and recommendations

The research in materials science is good. The focus of the research is appropriate, but the use of the in-house equipment should be increased. The theoretical activities are very scattered and the overall assessment is poor. The relatively oversized theoretical group is not successful, and the committee recommends strengthening the materials science efforts with a graduate student and to fill empty faculty positions with experimentalists in materials science. The equipment that is available at Stavanger as well as the opportunities at the ESRF and at Kjeller ought to be fully exploited. Furthermore, arrangements should be made for the researchers at Stavanger to have regular contacts with active groups at the major research centres in Norway.

4.8 Institute for Energy Technology

4.8.1 Physics Department

The Institute for Energy Technology runs a neutron scattering facility at the JEEP II reactor at Kjeller. This reactor, built in 1967 as a successor to Norway's first neutron reactor, which had been built in the year 1951, is a 2-MW facility providing thermal neutron beams with a maximum flux of 2.5×10^{13} n/cm^{2}s. The physics department at Kjeller utilises these relatively low-flux neutron beams for neutron studies in condensed-matter research. A series of advanced neutron diffractometers and spectrometers are available for powder and single-crystal neutron diffraction as well for small-angle neutron diffraction and time-of-flight spectroscopy. In addition, the reactor is used for radioisotope production and for doping silicon crystals by nuclear reactions. The neutron-scattering activity of the Physics Department at Kjeller constitutes something like a national facility for neutron-based materials research in Norway. It is intended to be a user facility with in-house research. The scientific staff consists of five scientists, including the head of the department. At present, two of the staff members (Skjeltorp and Hauback) hold adjunct professorships at the University of Oslo (Department of Physics and Materials Science Centre).

In the past five years, the research activities of the staff members of the Physics Department have been mainly in the fields of hydrogen-storage materials, catalysis, high-temperature superconductivity, and soft condensed matter. Some of this work has been performed in collaboration with scientists from the Department of Chemistry of the University of Oslo (catalysis and high-temperature superconductivity) as well as with other researchers from universities in Norway and abroad (e.g. from the Charles University Prague). Every second year (since 1971), the department organises a Nato Advanced Study Institute at Geilo. In addition, four of the staff members of the Physics Department (Helgesen, Knudsen, Hauback) and Fjellvåg (adjunct professor from UiO) have substantial experience in the use of synchrotron radiation; Helgesen through a two-year stay at the National Synchrotron-Radiation Light Source at BNL and Knudsen through a four-year stay at the ESRF. The expertise in the use of both neutron-diffraction and modern X-ray diffraction methods for the study of condensed matter gives a particular strength to the department.

The research output of two of the researchers at the Physics Department has been very good in the past five years: Hauback, mainly in the field of hydrogen-storage and magnetic materials, and Fjellvåg, mainly in the field of ternary intermetallic compounds of lanthanides and transition metals. Knudsen has also had a good scientific output in the field of organic materials and fullerides, obtained with both neutron- and X-ray diffraction. The same is true for Steinsvoll who also works in the field of magnetism. Helgesen has participated in a number of pioneering resonant magnetic X-ray diffraction projects while at BNL; however, his more recent publication record, particularly in the field of neutron applications, is poor.

4.8.1.1 Assessment and recommendations

There is no doubt that the Physics Department at Kjeller forms a strong group in materials science using neutrons and synchrotron radiation. The project on hydrogen storage is appropriate to the scientific opportunities at Kjeller. The outside user community from Norwegian universities seems to be rather small, particularly at the institutes of physics.

The field of hydrogen storage is not at all new and the research activities should be concentrated on the synthesis and analysis of new and potentially applicable storage materials. To be successful, the group should definitely build up its own materials preparation facility including equipment for hydrogen loading.

Special measures should be taken to strengthen the outside user community as well as condensed-matter research making use of the available neutron- and synchrotron-radiation opportunities at Kjeller and at the ESRF.

4.9 Norwegian Defence Research Establishment

4.9.1 Space Physics group

The Space Physics group at Norwegian Defence Research Establishment (FFI), Kjeller, is formed by five scientists, one chief scientist (Thrane), two principal scientists (Blix and Hoppe) and two senior scientists (Lie-Svendsen and Svenes).

The group's main efforts are in middle atmosphere physics (Thrane, Blix, and Hoppe). They employ the whole range of modern measurement techniques (radar, lidar, and rockets, with the latter instrumentation built in-house). They co-operate with many international groups and UiT and have international recognition in this field. Publication and citation rates range between very good and good during the past six years.

The junior members of the group engage in theoretical studies of outflow from the polar ionosphere and the solar wind (Lie-Svendsen, with ITA at UiO) and in building satellite instrumentation for CLUSTER and the CASSINI-mission to Saturn (Svenes). While the theoretical studies have resulted in some publications, the experimental work has just finished and the data interpretation is still to come.

4.9.1.1 Assessment and recommendations

This group is strongest in middle-atmosphere physics, where the overall rating is very good. The theoretical studies can be rated as good to fair, while no scientific rating is possible for the hardware efforts at present. While close co-operation within the Norwegian CLUSTER team might provide reasonable scientific output in this field, it is not seen how that can be achieved for the CASSINI mission to Saturn.

The group should clearly concentrate on the middle atmosphere. Some space plasma physics effort is encouraged, but should concentrate on the lower ionosphere, i.e., the interface between a strongly collision-dominated plasma fluid and a regime where kinetic effects start to play a bigger role. Such an effort can only be successful by good co-ordination between theory (simulations) and experiment (observations by radar and rockets).

The present size of the group is both necessary and sufficient.

5 General conclusions and summary of recommendations

5.1 A new career structure

The evaluation committee strongly recommends that a new career structure be created. Young people should be offered a visible system with fellowships for foreign postdoctoral studies and possibilities for postdoctoral and longer fixed-term positions at the Norwegian universities and institutes, giving possibilities for qualifying for tenured positions. A tenure track system should be considered.

The high number of retirements during the next decade will provide the institutions affected with the opportunity to make dedicated efforts in modern areas of physics. However, we recommend that some of the permanent positions be converted, at least for a time, into postdoctoral and other longer fixed-term appointments including tenure-track ones. This will lead to a continued possibility of hiring new staff, i.e. there will be career opportunities for young scientists and a healthy environment in which existing areas of research will gain renewed strength and new ideas can be brought in and given room to flourish.

The committee strongly recommends that the universities, institutes, and the Research Council give high priority to creating powerful postdoctoral programs. There are good examples in other countries of such programs directed towards fields that should be strengthened. This could be a possibility to strengthen research in areas that are weak in Norway today and to open up new areas, such as e.g. biophysics, branches of condensed-matter physics, laser physics and non-linear optics. Postdoctoral fellowships for going abroad for a couple of years followed by a second postdoctoral period at a Norwegian university should be considered. Young promising scientists should be identified for such positions and care should be taken to give them adequate resources for research when they return to Norway (a good possibility for co-operation between a university and the Research Council). A "tenure track" system suitable for stimulating the best young scientists for academic careers should be considered.

5.2 Stimulation of mobility, counteracting inbreeding

As Norway has few universities, all fields cannot be represented at each university. This causes difficulties to obtaining mobility within the country and there is a risk of inbreeding. Universities and the Research Council should be aware of this serious problem and all possible means should be sought to stimulate people to move between universities when possible, and to get experience abroad.

It is most important that young people as a rule go abroad for postdoctoral research and preferably return to other universities than where the graduate studies took place. Such mobility could be stimulated by various measures. For instance, by the mechanism suggested in the preceding section, i.e. increased economic support to excellent young scientists returning to Norway after a postdoctoral period abroad

The risk for inbreeding could be reduced significantly by ensuring good international interactions and participation in international networks. This gives possibilities for frequent visits in foreign environments for staff and students. Good networks strongly facilitate possibilities for the young Ph.D.s to find good places for postdoctoral studies abroad. Possibilities should be sought to recruit new staff from abroad. The universities are strongly recommended to announce new positions internationally and to be active in international recruitment of new faculty for key positions. The Research Council and the universities could in such procedures co-operate to create attractive conditions concerning salaries, supporting positions and student positions as well as research grants. Similarly programs for regular visits in Norway by guest professors and guest scientists should be created to stimulate and develop the scientific activities at the university departments and scientific institutes.

5.3 Mechanisms for development of long term strategies

As emphasised in sections 5.1 and 5.2. initiatives should be taken to strengthen the career system, increase international interactions and stimulate mobility. In the recommendations in chapter 4 and in the following sections of chapter 5 of the report, the evaluation committee proposes a number of new initiatives and also the phasing-out of some existing activities. There is also a strong recommendation of the evaluation committee to focus activities in several of the departments and institutes.

Independent of possibilities of increasing the funding to Norwegian physics, the evaluation committee strongly recommends universities, research institutes and the Research Council to create mechanisms for working out long term strategies for making changes in the group structure, career system and research fields. The financial resources should be focused on research areas as well as on scientists and groups of scientists where they can be expected to have maximum impact. This should be done fast in view of the many retirements in the near future.

The roles of the Research Council and the governing bodies of the university departments and research institutes should be to create the incentives for working out strategies. This could be done by requirements of strategy documents and setting up working procedures. The existing scheme of the Research Council for funding basic research programs should be developed with emphasis on the need to plan for the future after the time-limited support from the Research Council. The plans should of course depend on the nature and success of a specific program.

The Research Council, the universities and research institutes should collaborate in finding models for stimulating increased collaboration between individual scientists and groups of scientists at the same department or institute as well as between groups from different locations. The Research Council's support to basic research programs is constructive in this respect. The evaluation committee, however advises the Research Council and the universities to also consider other programs (e.g. of the German model "Sonderforschungsbereich"). Regular external and international evaluation of such programs is strongly reccommended.

Increased funding from the Research Council for e.g. international collaborations (fellowships, guest professors, etc.) and scientific equipment would help in the development of powerful strategies for the future.

Even though the evaluation committee proposes new programs and the phasing-out of some existing activities, it strongly recommends that the Norwegian scientists be involved in the work of changing structures and activities. The evaluation committee essentially proposes bottom-up procedures with the best Norwegian scientists involved with advice from international experts.

5.4 Applied Physics

Research of an applied nature is carried out by the electronics group within the Department of Physics of UiO. The work has a low physics profile, but is attractive to cand.scient. and dr. scient students. The evaluation committee recommends the CERN-related work and activities in hydroacoustics to be continued, while the activities in physical electronics should be phased out. The biomedical engineering work within the electronics group is recommended to be transferred to strengthen the biomolecular research within the department.

The Department of Physics within UiB has during the 80's and 90's made a redirection from almost exclusively basic research towards applied research and technological development. This conscious strategic move is appreciated by the evaluation committee. The section of Applied Physics and Technology has a very good record of cand.scient. and dr.scient. graduation with a steady flow of graduates into Norwegian industry. The evaluation committee agrees with the plans presented that very little should be changed in the near future in this section. Retirements within the coming years should be filled again with young researchers in order to strengthen the presently successful activities. Attention should be put on increasing the publication output.

At NTNU the Medical Technology group within the Department of Physics is recommended to strengthen its contacts with other biomedical-technological activities in an effort to create a new experimental activity in biomaterials/soft-condensed matter. The group should include the vision research at NTNU and strengthen technology-oriented work.

The initiative in the beginning of the 90's of the Department of Physics in UiT to create activities in applied physics in order to increase the attractiveness of Tromsø to students has led to a new teaching program and building up of new student training facilities. The evaluation committee finds, however, that the Applied Physics group has a rather incoherent research profile. Part of the activities within the Applied Physics group should be considered to be directed towards participation in a strategic effort to increase activities in biomedical technology in a collaboration with the University Hospital in Tromsø. Another recommendation is that some of the staff members within the Applied Physics group should focus their attention on a new initiative in atmospheric physics at UiT in order to strengthen the scientific base of their activity.

The Physics section at the Department of Agricultural Engineering at AUN has gone trough a major expansion in the 90's. New young staff members have been hired and an attractive educational program in basic physics has been established. The evaluation committee recommends a focusing of the physics activities into two areas, in order to create a more coherent research profile, namely the formation of a section for Applied Agricultural Physics and a section for Biological Physics and Physics of Complex Systems. The section for Applied Agricultural Physics should include the present activities in agricultural meteorology, bioenergy and some of the activities in agrophysics. The evaluation committee also recommends to put more attention in the future on an increased publication output.

5.5 Atomic, Molecular and Optical Physics

The committee did not identify a critical experimental activity in basic research in atomic, molecular and optical physics nor in related areas such as non-linear optics, laser physics, and quantum electronics. Internationally these are important disciplines in physics and it is the opinion of this committee that these should be represented in Norway at least at one location. Therefore the committee advises taking a new initiative in non-linear optics and femtosecond laser spectroscopy, since this opens up numerous possible new research lines in condensed matter and materials science and allows interdisciplinary activities involving chemistry and biosciences. This activity should be localised at NTNU where it can exploit the presence of the strong group in condensed matter theory. Significant funding for a femtosecond laser facility is required (of the order of 10 MNOK plus dedicated laboratory space), which should be jointly provided by the Research Council of Norway and NTNU based on a strategic plan, including the identification of suitable scientific personnel.

At UiT the committee advises to take an initiative in atmospheric physics that explicitly includes a new in-house activity in molecular physics related to physical processes in the atmosphere, involving both experiment and theory.

5.6 Astrophysics

The scope of research carried out by astronomers in Norway is narrow; and there is little if any interaction between astronomy and astrophysics programs at different Norwegian institutions. But, in selected areas, the astrophysics research is of high international standard. This is true especially in solar physics, as well as in a very small number of selected areas in which a single faculty member maintains a very good research program (Havnes' program in Tromsø is the best example). It is clear that the present size of the faculty at ITA is needed to maintain the high-quality research done there.

Norwegian astrophysicists have recognised that international collaborations are essential to maintaining their scientific vitality. The ITA, and the astronomical efforts at Tromsø, provide a number of examples of successful efforts in this direction.

The only critical mass astrophysics research program of international stature is in solar physics; all other research programs in astrophysics are basically one or two-faculty member efforts. These non-solar astrophysics programs in Norway need to be co-ordinated and selected field(s) e.g. cosmology need to be strengthened.

The future of forefront ground-based optical astronomy is very likely to centre around the use of automated moderate-sized, wide field telescopes with large area focal plane detectors working in survey modes, and adaptive optics-equipped very large aperture telescopes carrying out high resolution spectroscopy of very faint objects. At present, Norway only has access to NOT, which has modest aperture and a small field of view, and is not designed to work in automated survey mode. Therefore it will be very difficult for Norwegian optical astronomers to compete in most areas of modern optical astronomy unless they gain access to other (possibly new) facilties, or carefully delimit their optical research programs to subjects for which the NOT can still productively be used. For this reason, Norwegian astronomers need to determine whether Norway's continued involvement with NOT makes scientific and economic sense; and whether Norway should take steps to obtain access to a larger-aperture telescope, or to a survey telescope.

5.7 Biological physics

Biological physics activities of supra-critical size in Norway take place in Oslo and Trondheim. Viable and qualitatively "good" nuclei of research in biological physics were identified at these locations, although a significant fraction of the research needs to be redirected. Furthermore, according to the committee, most of the current activities in biological physics in Norway have only to a very limited extent been inspired by recent developments in physical methodology or molecular and cell biology. Given that the 21st century will show the integration between biology and physics in many important subfields, and as a consequence will experience a worldwide boost in activities, the committee strongly advises:

- Initiating a new program in biological physics at UiO that capitalises the major progress that has been made in optical/laser physics. This new program should build on a strong physics background, while at the same time it should be fully integrated in an interdisciplinary program involving chemistry, biology and medicine.

- Initiating a new program in biomaterials/soft condensed matter at NTNU that builds on the local expertise in biomolecular assemblies and the excellent research in theoretical condensed matter physics.

- Initiating new programs at the interface of applied physics and biomedical technology at NTNU and UiT. These new programs should build on a strong, local infrastructure in medicine, applied physics and (molecular) biology.

- Initiating an interdisciplinary program for physical and mathematical modelling of biological molecules and biomolecular events in the living cell at AUN.

5.8 Condensed matter physics/materials science

Given the international role of condensed matter physics, it is hard to understand that this very important field of physics is playing such a minor role in Norway's experimental physics research. The situation is even worse if one considers the research fields of the staff members active in condensed-matter physics/materials science. The larger part of the experimental research is related to structural work (diffraction; electron microscopy), i.e. rather classical and fully established methods, which are definitely important for the field as analytical tools, but are not at the forefront of present-day research. In addition, the small activity in condensed-matter research is mostly unfocused and little co-ordinated, with the consequence that almost none of the groups reach a critical mass in a certain field in order to follow or even determine the forefront of present-day research.

Almost all of the main research fields in experimental condensed-matter research have been missed in Norway. There is practically no semiconductor research going on, and fields like solid-state magnetism, low-temperature physics or nano-scale materials, to name just a few, are practically absent. There is a tiny, reasonably focused surface-physics activity at NTNU, but most of the condensed-matter research at UiO and NTNU is rather dispersed.

It is therefore essential that mechanisms be introduced by the universities and funding agencies that stimulate the formation of a few focused research activities of high current interest in the field of condensed-matter physics/materials science at Norwegian universities, which can reach the necessary critical masses in the various fields. Such a process must involve the present researchers and take into account the present strengths as well as the envisaged goal and requirements. There is no doubt that all departments of physics at the four major universities in Norway should offer teaching and graduate research in condensed-matter physics/materials science, with the necessity of fine-tuning the focused special fields pursued at the various departments on a national level in order to avoid duplication.

5.9 Space physics

In general, space physics in Norway is doing very well, especially if compared to other fields. The quality of the scientific work in space physics is very good to good and internationally recognised (to reach international top level, publication frequencies and citation rates have to be approximately doubled). There is a lot of good international co-operation, but national co-operation between the different groups or within the physics departments is often at too low a level.

Laboratory plasma physics is subcritical and does not meet international standards. This activity at UiT should be phased out.

The outlook for space plasma and middle atmosphere physics in Norway for the immediate future is quite bright. Better co-operation between the different space plasma physics groups during the upcoming CLUSTER-II satellite mission is encouraged and might enhance scientific output.

In the long run, streamlining or reshuffling of the activities in space plasma and atmospheric physics within and between the different groups is needed and will result in synergy effects. The biggest change proposed by the committee is to phase out space physics at UiB and move space-borne instrument building to UiO. However, this can only be done if the size of the UiO group is increased, since a strong effort in space-borne instrumentation is essential for keeping Norway at the forefront of space physics.

The cosmic geophysics activities at UiT need continued support at the present level to stay competitive internationally. The same holds for the space and atmospheric physics efforts at FFI. The successful efforts at UNIS should be strengthened. The proposed new effort in atmospheric and molecular physics at UiT needs reshuffling of some of the positions there.

For a viable future of space physics in Norway, the total number of positions assigned to the field needs to stay at the present level.

5.10 Subatomic physics

The high-energy physics program is oriented towards participation in large international collaborations. The quality of the scientific work is very good and the contribution of the Norwegian groups to the experiments is focused and very notable, especially in the CERN based program. It is important that the level of support to high-energy physics remains adequate also in the future to fully exploit the important investment in the LHC program.

However, the size of the Norwegian groups is small and a further focusing of the existing resources on the main CERN program should be considered. On the other hand during the years 2001-2005 the accelerators at CERN will be closed while LHC will be installed. During this period, participation in a limited activity in a running experiment outside CERN would allow access to new data and would be beneficial for students. The Oslo and Bergen groups should consider the possibility to engage in such activities, weighing the advantage of the access to the new data against the lower impact on the CERN program.

Low energy experimental nuclear physics should be discontinued and the experimental activity in nuclear physics should be focused on the ultrarelativistic heavy ion collision experiments.

5.11 Theory

In theory there are a number of productive groups. The most conspicuous is the one in condensed matter theory at NTNU. In addition there are smaller groups, those at UiO working on field theory and related problems, and on nuclear theory, and the two faculty members at UiB working in atomic physics. Another very good group is that at UiO working on both theory and experiment related to complex systems. Apart from that, theoretical research is mainly carried out by individuals working largely in isolation. The total number of positions in theoretical physics in Norway is reasonable, but more impact could be achieved by a greater degree of co-operation between faculty members.

At UiO and NTNU the present group structure seems unhealthy, and steps should be taken to change this with a view to creating environments for theory that are broad, and which have greater impact.

Many faculty members could be more productive if they had colleagues to work together with. We recommend that this be facilitated by funding more postdoctoral fellows and senior visitors. At UiO the appointment of professors II has been exploited to bring in prominent physicists from abroad whose expertise complements that of the faculty, and this has had a healthy effect on the host groups. This model should be considered at other universities.

International collaboration is absolutely essential for progress in theory, but it is not sufficient. Greater attention should be paid to establishing contacts to, and building up relationships with, groups outside Norway that are at the cutting edge of research.

The practice of supporting the very best Norwegian students to do their graduate work at major centres abroad has been a great success, in that many of the most prominent faculty in theory followed this path. This program, which provides an important part of the talent pool for future faculty appointments, should be continued and strengthened. More generally, the support of promising young theorists, both in terms of salary and in terms of building environments where they can flourish, is crucial for ensuring the future vitality of theoretical physics in Norway. For many years a workshop in theoretical physics for students was held in Trondheim. This played a useful role in introducing new fields of research, and the possibility of reviving it should be considered.

To counteract the fragmentation of theoretical research in Norway, we propose that steps be taken to build up communities of theorists in the country. In the past this has been done by support of collaborative research by a number of faculty members.

There are some areas that are under-represented in Norway. One is materials science, and, as stated in the section in condensed matter physics, it is important to build up theory in this area in conjunction with the proposed strengthening of the experimental effort. There is little work in atomic, molecular, and optical physics, and this should be strengthened. In subatomic physics, an important area that should be strengthened is the interface between particle physics and cosmology.

As far as the overall level of support is concerned, the committee has the impression that areas that have a readily perceived relevance to real-world problems, such as, for example, ones in the oil industry, are supported at a reasonable level. However, support to other areas of theory appears to be merely at a subsistence level. This makes it very difficult to carry out world-class physics in these other areas, and in addition exacerbates conflicts between faculty members. Support to these areas should be increased.

6 Appendices

Appendix 1

Curriculum Vitae for the committee members

Örjan Skeppstedt

Örjan Skeppstedt received his Ph.D. in physics (1972) from the University of Gothenburg. After a postdoctoral period at Texas A&M University in USA he returned to Gothenburg and Chalmers University of Technology, where he worked as research associate, lecturer and research scientist. In 1997 he was appointed professor. His research field is accelerator-based nuclear physics and he has been active in the Nordic and European multidetector projects NORDBALL and EUROBALL with a special interest in the structure of neutron deficient nuclei.

Skeppstedt was a member of the Swedish Natural Science Research Council 1992-1999, and its deputy chairman 1995-1998. He was chairman of its program committee of physics 1992-1998 and he was scientific delegate, representing Sweden in the CERN Council (nominated by the government) 1989-1998.

From 1999 Skeppstedt is director for the Manne Siegbahn Laboratory in Stockholm, which is a Swedish national facility with the accelerator complex CRYRING, which is used for studies of atomic and molecular collision physics.

Wolfgang Baumjohann

Wolfgang Baumjohann studied Physics and Geophysics at the University of Münster, where he received his Ph.D. in 1980. He currently works as Senior Scientist at the Max-Planck-Institute für extraterrestrische Physik in Garching and teaches Space Plasma Physics at the University of Munich.

He has worked on auroral electrodynamics, magnetospheric convection, magnetotail dynamics, substorms, pulsations, and plasma waves, employing ground-based, rocket, and satellite instrumentation and data. He has authored and co-authored more than 230 papers in scientific journals and written three books, one monograph on magnetosphere-ionosphere coupling (with Y. Kamide) and two textbooks on space plasma physics (with R.A. Treumann).

He has served as chairman or member on more than a dozen scientific committees or editorial boards. At present he chairs the German Space Research Community, and is a member of the German COSPAR Committee, of the ICSU-SCOSTEP Long Range Planning Committee, and of the Editorial Board of Imperial College Press.

Rienk van Grondelle

Rienk van Grondelle studied experimental physics at the Vrije Universiteit Amsterdam in the Netherlands. He obtained his Ph.D. in biophysics at the University of Leiden in 1978. Between 1978 and 1983 he worked as a postdoctoral fellow at the University of Bristol (UK) and at the University of Leiden, where he became involved in ultrafast laser spectroscopy. In 1983 he moved to the faculty of Physics and Astronomy of the Vrije Universiteit in Amsterdam where he initiated a research program on ultrafast events in biological systems, in particular studying the primary processes of photosynthesis. In 1987 he became a full professor and currently he is the head of the Department of Biophysics and Physics of Complex Systems, applying a variety of advanced laser techniques to study biological systems. He has been a member of the executive board of the Foundation for Earth and Life Sciences, is currently a member of the committee for Physical Biology and has served on many grant selection committees of the Netherlands Organization of Scientific Research. He is on the editorial board of the Journal of Physical Chemistry, Chemical Physics Letters, Biochimica Biophysica Acta (Bioenergetics) and an associate editor of Photosynthesis Research. Finally, he is the co-author of the book ”Environmental Physics”.

Günter Kaindl

Günter Kaindl was born in Augsburg, Germany, and studied physics and engineering at the Technical University München, where he received his doctoral degree in physics (1969) with R.L. Mössbauer. He was then a recipient of a Miller award from the University of California at Berkeley (1969), where he spent his postdoctoral years, working in the field of hyperfine interactions with Mössbauer spectroscopy, nuclear orientation, and nuclear magnetic resonance. At present, he is a full professor of physics at the Freie Universität Berlin (since 1976), following an associate professor appointment at the Ruhr-Universität Bochum (from 1974-1976). In 1997, he received an honorary doctoral degree from St. Petersburg State University, Russia.

His main research is in condensed-matter and surface physics, and he and his group are particularly interested in the electronic structure of highly correlated materials (3d, 4f, and 5f transition elements) as well as in the growth, structure, and magnetism of thin films and nano-systems of these materials. He uses a number of experimental techniques to study these materials, including high-energy spectroscopic methods (photoemission, x-ray absorption, x-ray emission), microscopic techniques (Kerr microscopy, scanning near-field optical microscopy, scanning tunneling microscopy) as well as x-ray diffraction (resonant magnetic x-ray scattering). He is an expert in the use of synchrotron radiation in condensed-matter and atomic/molecular physics research and is also working on the highly correlated doubly excited states of helium. He has authored more than 350 original papers in international scientific journals.

Günter Kaindl served on several national and international committees, including the science advisory committee of the European Synchrotron-Radiation Facility. At the Freie Universität Berlin, he was dean of the physics department and vice president for science and research. He was a visiting professor/researcher at various institutions in the U.S.A., including UC Berkeley, Stanford University, University of Wisconsin at Madison, and the IBM Research Center in Yorktown Heights.

Christopher Pethick

Christopher Pethick is Professor of Physics at Nordita, the Nordic Institute for Theoretical Physics in Copenhagen. He was born in England, and educated at the University of Oxford, where he received his D. Phil. degree in 1965. From 1966-1969 he was a postdoctoral fellow at the University of Illinois, where he became a member of the faculty in 1970. In 1975 he took up his present position at Nordita, but retained his strong links to the University of Illinois, where he spent considerable amounts of time until 1988.

His main research interests lie in the theory of many-particle systems in condensed matter physics, astrophysics, and nuclear physics. His early work was on liquid helium and electrons in metals. Subsequently he worked extensively on the properties of neutron stars, especially on the properties of matter at high density. Other fields of interest have been the properties of the superfluid phases of liquid helium 3, non-equilibrium properties of superconductors, strongly-correlated systems, and aspects of nuclear physics. Over the past five years, the main focus of his research has been the theory of ultra-low temperature clouds of atomic gases, especially Bose-Einstein condensation.

The positions he has held include being member of the board of ECT*, the European Centre for Theoretical Studies in Nuclear Physics and Related Areas in Trento, and associate editor of Reviews of Modern Physics. He is at present a member of the National Advisory Committee of the Institute for Nuclear Theory in Seattle, USA.

Gigi Rolandi

Gigi Rolandi received his Ph.D. (1978) in Particle Physics from the Scuola Normale Superiore in Pisa. He is senior research physicist at CERN (European Organisation for Nuclear Research) and was associate professor at the University of Trieste.

His main research field is electroweak physics and precision tests of the Standard Model. He made notable contributions to the measurement of the line-shape of the Z boson and to the measurement of the electroweak asymmetries. During the years 1989-1997 he had central responsibilities (analysis co-ordinator and later spokesman) in the Aleph experiment, one of the four experiment running at LEP, the large electron positron collider of CERN.

Since 1998 he joined the CMS Collaboration that is constructing one of the two big detectors for the Large Hadron Collider (LHC). The LHC will be built at CERN to take data in 2005. He has the responsibility of the construction of the Central Tracker. This project involves about 300 physicists from 40 universities and laboratories in Europe and United States.

He served in many international scientific committees dealing with particle physics: LEP-Committee (CERN), LHC-Committee (CERN), SLAC Experimental Program Advisory Committee, UK Particle Physics Experiments Selection Panel, DESY Physics Research Committee.

Gigi Rolandi wrote a book on particle detectors: "Particle Detection with Drift Chambers" and is co-author of more than 250 papers in international journals.

Robert Rosner

Robert Rosner received his Ph.D. in Physics (1976) from Harvard University. He was a postdoctoral fellow at the Harvard-Smithsonian Center for Astrophysics (1977-78); an assistant and associate professor in astronomy at Harvard University (1979-86); and, since 1987, a professor of theoretical astrophysics in the Department of Astronomy & Astrophysics and the Enrico Fermi Institute at the University of Chicago. He has been a Visiting Professor at the University of California/Berkeley (1983); was chairman of the Department of Astronomy & Astrophysics at the University of Chicago from 1991 to 1997; and since 1998 has been the William E. Wrather Distinguished Service Professor.

Most of Rosners scientific work has been related to astrophysical fluid dynamics and plasma physics problems. He has worked on theories for stellar coronae, winds, and activity; models for stellar x-ray emission from early and late-type stars, and x-ray luminosity functions; stellar bolometric luminosity variations; helioseismology; and models for stellar interiors and stellar evolution. He has also worked extensively on a variety of magnetohydrodynamic problems, including the nonlinear evolution of Kelvin-Helmholtz instabilities and magnetic field generation by magnetic dynamos; and applications of these studies to systems ranging from astrophysical jets and accretion disks to galaxy cluster halos and "cooling flows". Much of his current work is involved in the development of new numerical simulation tools for modeling the transient behavior of nuclear burning in evolved compact stars (white dwarfs and neutron stars); related to this work are studies of turbulent mixing in nonlinear Rayleigh-Taylor and other mixing flows. In the realm of applied mathematics, Rosner has worked on applications of stochastic differential equations, optimization theory, and regularization techniques for inverse methods.

Among his various scientific community services relevant to this study, Rosner was chairman of the US National Academy of Sciences Committee on Solar Physics (1987-1989) and of its Astronomy Survey Committee ["Decadal Survey"] Solar Physics Panel (1989-1991); was a member of the American Physical Society (APS) Astrophysics Division Executive Committee (1990-1992) and the chairman of its nominating committee (1994-1995); was chairman of the Visiting Committee for the Harvard-Smithsonian Center for Astrophysics (1995); has been a member of the Board of Directors of the American Universities in Research in Astronomy (AURA) (1997-1999); was a member of the US National Academy of Sciences Committee on Astronomy & Astrophysics (1996-1998), of the US NASA Information Systems and Science Operations Working Group (1996-1998), and of the US National Academy of Sciences "Solar Physics from Ground" ("Parker") Committee (1997-1998); was a member of the US National Academy of Sciences Committee on Computational Physics (1997-1998); is a member of the US National Academy of Sciences Committee on Plasma Sciences (1999-present); and is currently chairman of the Theory Panel of NAS Fusion Science Advisory Committee (1999-present).

Appendix 2

MANDATE FOR THE REVIEW OF RESEARCH IN PHYSICS AT NORWEGIAN UNIVERSITIES AND COLLEGES

Purpose of the review

The Division of Science and Techonology at the Research Council of Norway, which is funding basic research in the universities and technological research institutes in Norway, has decided to draw up strategic plans for the research in its various fields of interest. As a part of this process, a review by an international group covering the field of physics will be carried out to obtain necessary background information. The review should include both theoretical and experimental aspects of the following subfields of physics: Particle physics, Nuclear physics, Atomic and Molecular physics, Solid state physics, Biophysics, Plasma physics, Optics, Physics of the middle and upper atmosphere as well as Astrophysics, and lead to a set of concrete recommendations to the Research Council concerning future developments in the field of physics research in Norway.

Background material

The evaluation committee will be presented with background material covering the following points:

- the fields which are represented in Norwegian research in the discipline of physics
- the structure of the academic departments
- the personnel according to posistion and age
- the funding of the research groups
- the scientific equipment
- data on publications and citations

Questions to be answered

1. Scientific activity and quality

- Which fields of research have a strong scientific position in Norway?
  Which have a weak position?

- Is there a reasonable balance between the different fields of Norwegian physics research? Or

- is research absent in particular fields, are some fields underrepresented? Or

- are some fields overrepresented, in view of the quality or scientific relevance of the research performed?

- How does the age distribution of today's physics personnel affect the quality of research?

- How is the balance between theoretical and experimental studies within the various fields? How does this compare to the situation in other countries?

- Do the research groups have a strategy/plans for the research which is carried out?

- Is the size and organisation of the research groups reasonable?

- Are the academic departments organised in an adequate way?

2. International and national collaboration

- Do the research groups take part in international programmes or use facilities abroad, or could the utilisation be improved by introducing special measures?

- Is there sufficient contact and cooperation with other research groups nationally and internationally?

- Which role do Norwegian groups play in international cooperation in various subfields? Are there any significant differences between Norwegian physics research and research in other countries?

- Is there reasonable cooperation and division of research activities on the national level? Or could this be improved?

- Is there cooperation related to the use of expensive equipment?

3. Training and mobility

- Is the recruitment to doctoral training satisfactory?
  Or should higher emphasis be put on recruitment in the future?

- Are there education and training opportunities for Ph.D.s in industrial research?

- Is the extent of mobility of young physicists satisfactory during their training period, nationally as well as internationally?

- Where do the candidates go after completion of their degrees?

4. Relevance of the scientific research

- Do the research groups have contacts with the Norwegian technical research institute sector or with Norwegian industry?

- Is today's research in physics relevant to the needs of Norwegian industry and society?

- Are the research groups prepared to solve tomorrow's problems, both nationally and internationally?

- How do the levels of publishing and citation rates compare with those of other countries?

5. Miscellaneous

- Other important aspects

Appendix 3

The letter from the Research Council to the Norwegian Universities (in Norwegian)

Til institutt/-avdelingsledelsen ved
institusjoner i følge vedlagte liste

Vår saksbehandler/telefon **Vår ref.** **Oslo, 26. mai 1999**
Synnøve Irgens-Jensen/2203 7250 99/ 01721 SIJ/sdu
sij@forskningsradet.no **Deres ref.**

Evaluering av norsk forskning i fysikk

Det vises til tidligere utsendt brev.

Norges forskningsråd ønsker å gjennomføre en evaluering av fysikk ved universitetene, de vitenskapelige høyskolene, de statlige høyskolene samt ved relevante forskningsinstitutter.

I henhold til vedtektene er en av hovedoppgavene for Norges forskningsråd *"å iverksette og følge opp evaluering av forskning og forskningsinstitusjoner"*. Norges forskningsråd og de tidligere forskningsrådene har samlet lang tradisjon og stor kompetanse når det gjelder evaluering av disipliner. De siste disiplinevalueringene Forskningsrådet gjennomførte var innen kjemi og geofag. Disse ble gjennomført i 1997 og 1998. Som et resultat av disse og med utgangspunkt i deres råd og konklusjoner utarbeidet Forskningsrådet egne fagplaner for disse fagene, som vil bli fulgt opp i de nærmeste årene, når bevilgninger gis. Liknende prosedyrer for fysikkfaget vil bli fulgt når denne evalueringen foreligger. Fagplanene skal gi råd om hvordan området for naturvitenskap og teknologi (NT) kan bidra til å utvikle og styrke fagene for å kunne møte dagens og morgendagens utfordringer. De skal også anbefale tiltak som U&H-sektoren bør gjennomføre innen egne budsjetter.

Vi vil tro at også universitetene vil finne evalueringene nyttige når det gjelder å utforme egne strategier for de enkelte disipliner. For overordnede nivåer, som bevilgende departementer, forventer vi at det vil anses som nyttig å få dokumentert hva tilstanden er innen de enkelte fag i norsk forskning og hvilke behov en internasjonal evalueringsgruppe vil påpeke og beskrive.

Egenrapport fra forskningsinstitusjonene
Rapportering fra institusjonene vil danne grunnlaget for arbeidet i evalueringskomiteen. Denne henvendelsen sendes til flere organisatoriske nivåer (i hht. vedlagte liste). Vi ber om at rapporteringen så langt mulig samordnes på instituttnivå eller på annet organisatorisk nivå der dette er naturlig. I det følgende er "institutt" benyttet som fellesbetegnelse for det som måtte være naturlig organisatorisk enhet i hvert enkelt tilfelle.

Vi ber om å få tilsendt følgende informasjon (10 – 20 sider avhengig av instituttets størrelse) **på engelsk både som papirkopi og på diskett innen 15. september d.å.** (egen frist for innsending av liste over de internasjonale fagtidskrifter, se side 2):

- Organisering av instituttet
- Beskrivelse av forskergruppene
- Vurdering av instituttets styrke, svakheter, muligheter og trusler
- Strategi og framtidige planer

Vi ber om følgende vedlegg

- Oversikt over vitenskapelig ansatte, inkludert stipendiater, angi alder og fagfelt
- CV for alle fast vitenskapelig ansatte; maks. 2 sider inkludert liste over publikasjoner siste 5 år. Legg ved 2 kopier av de 5 viktigste artikler siste 5 år
- Liste over større utstyrsenheter
- Oversikt over større investeringer siste 5 år
- Annuum-bevilgninger siste 5 år
- Eksterne forskningsbevilgninger siste 5 år med angivelse av kilde
- Oversikt over uteksaminerte hovedfags- og doktorgradskandidater med veileder siste 5 år. Angi tittel på doktorgradsarbeidene. Hva slags arbeid eller stilling gikk kandidatene til etter avsluttet eksamen?
- Beskrivelse av nasjonalt og internasjonalt forskersamarbeid
- Beskrivelse av samarbeid med industri og offentlig forvaltning
- Årsrapporter siste 5 år
- Liste over de internasjonale fagtidskrifter hvor hovedtyngden av de vitenskapelig ansattes arbeider publiseres. **NB! Det bes om at denne liste sendes inn snarest mulig, og innen 1. juli d.å. på grunn av NIFU-oppdrag**

Evalueringsmaterialet fra institusjonene vil bli bearbeidet og oversendt evalueringskomiteen. Som tidligere nevnt vil møter mellom evalueringskomiteen og forskergruppene trolig bli avholdt i Oslo i løpet av desember 1999, og evalueringsrapportene vil bli ferdigstilt i løpet av 1. kvartal 2000.

Med vennlig hilsen
Norges forskningsråd

Nils Marås
Kst. områdedirektør
Naturvitenskap og teknologi

Synnøve Irgens-Jensen
Spesialrådgiver
Prosjektleder

Kopi: Ledelsen ved universiteter, fakulteter og høyskoler i følge vedlagte liste

Institutter som skal inngå i evalueringen

Universitetet i Oslo

- *Det matematisk-naturvitenskapelige fakultet:*
  - Fysisk institutt
  - Institutt for teoretisk astrofysisk

Universitetet i Bergen

- *Det matematisk-naturvitenskapelige fakultet:*
  - Fysisk institutt

Norges teknisk-naturvitenskapelige universitet

- *Fakultet for fysikk, informatikk og matematikk:*
  - Institutt for fysikk

Universitetet i Tromsø

- **Det matematisk-naturvitenskapelige fakultet**

  - ***Institutt for fysikk***

Norges landbrukshøgskole

- *Institutt for tekniske fag, Seksjon for fysikk og grunnleggende ingeniørfag*

Universitetsstudiene på Svalbard

Ved universitetsstudiene på Svalbard er det bare et fåtall av forskerne som kan kategoriseres som fysikere. Disse bør imidlertid omfattes av evalueringen.

Statlige høgskoler

Gruppe for generell teoretisk fysikk, samt gruppe for materialvitenskap ved Høgskolen i Stavanger bør omfattes av evalueringen.

Institutt for energiteknikk (IFE)

Gruppe for nøytronfysikk.

Forsvarets forskningsinstitutt (FFI)

Gruppe for romfysikk innen avdeling for elektronikk

Appendix 4

List of abbrevations

AUN	Agricultural University of Norway
AVH	College of General Science
FFI	Norwegian Defence Research Establishment
GUF	General University Funds
ITA	Institute for Theoretical Astrophysics
IFE	Institute of Energy Technology
ISI	Institute of Scientific Information
NIFU	Norwegian Institute for Studies of Research and Higher Education
NTH	Technical University of Norway
NTNU	Norwegian University of Science and Technology
UiB	University of Bergen
UiO	University of Oslo
UNIS	University Courses on Svalbard
UiT	University of Tromsø