



UNIVERSITY OF HELSINKI



DEPARTMENT OF PHYSICAL SCIENCES

ANNUAL REPORT 2004

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Preface

2004 was the first year under the newly reorganized administration of the University. Since our Department has functioned as a pilot institution already during the preparatory years, the delegated rights to make decisions according to the new administrative rules have not meant a large change in our administrative activities. The faculty activities were more focused than before, during the era of the larger Faculty of Science. The centre of mass of decision-making has moved from the Faculty towards departments. When the services of the central administration were fully reorganized during the year, the activities of the trio formed by departments, faculty and campus services have gradually taken on a new form.

The widely representative campus negotiating body belonging to the new administrative structure has been enterprising in many respects during the year and clearly promoted common interests. Units

under contract and not directly belonging to the University, such as health and printing services and a bookstore, have also initiated their activities, thus improving the campus services.

During the year there have been many changes in the personnel, both in the number of positions, job descriptions and nominations. These are explained in the Personnel section of the Appendix. Among our retired long-serving members of personnel we are sad to report that professor emeritus Erik Spring and laboratory master Arvi Kuusikko have passed away.

The transition to a new payroll system in the University next year was reflected from the early autumn in the large number of bilateral development discussions. In the new payroll system the old salary classification will be abandoned, and the salaries will be based on the task demands and the work output.

There was a high level of research during the year and the number of peer reviewed publications reached 250, the record level last year. The reports from the evaluation of the geosciences performed last year by the Academy of Finland gave a very good estimate of the work done in our Department and emphasized the status of our campus as an important centre in this field in our country. The international research project in atmospheric sciences iLE-APS (Integrated Land Ecosystem – Atmosphere Processes Study), which started in our Department is to a great deal based on the internationally appreciated research work performed by our scientists. The International Aerosol Fellow Award 2004 received by Professor Markku Kulmala, the Nordic reward in aerosol research granted to professor Kaarle Hämeri and the Norbert – Gerrier MUMM International Award received by professor Timo Vesala together with an international research group show the appreciation of the research performed in our Department.

The measurement station built in cooperation with the Finnish Meteorological Institute and the Department of Chemistry, and the developments of a new generation weather radar station in cooperation with the Vaisala Oyj have been important research projects. As a whole, cooperation with the Finnish meteorological institute has made good progress during the year. The cooperation involves also the creation of a new joint chair of experimental meteorology with the Finnish Meteorological Institute and Vaisala Oyj.

The organization of scientific conferences and meetings has been based both on the international status of our research and the possibilities offered by the facilities in Physicum. The CERN 50-years anniversary ceremonies highlighted the research work done by our particle physicists.

The development of education is connected with the transition to the new two-step degree structure, which will be realized next year. The preparation means a good deal of work. The curriculum core content analyses and estimates of the workload have been of major importance for the new educational planning. The development of the new degree system has benefited greatly from the experience and

work contribution of professor Seppo Manninen, both in our Department and the whole Faculty.

The LUMA centre founded in the Faculty has already proved to be important for the promotion and support of education in sciences and mathematics. The large cooperation it carries on with the educational administration, industry, schools and teachers is remarkable. The experience of subject teachers' education in our department has given it a visible position in the activities of the LUMA centre.

The education in our department achieved distinction in the university, since we received one out of the six quality rewards for education.

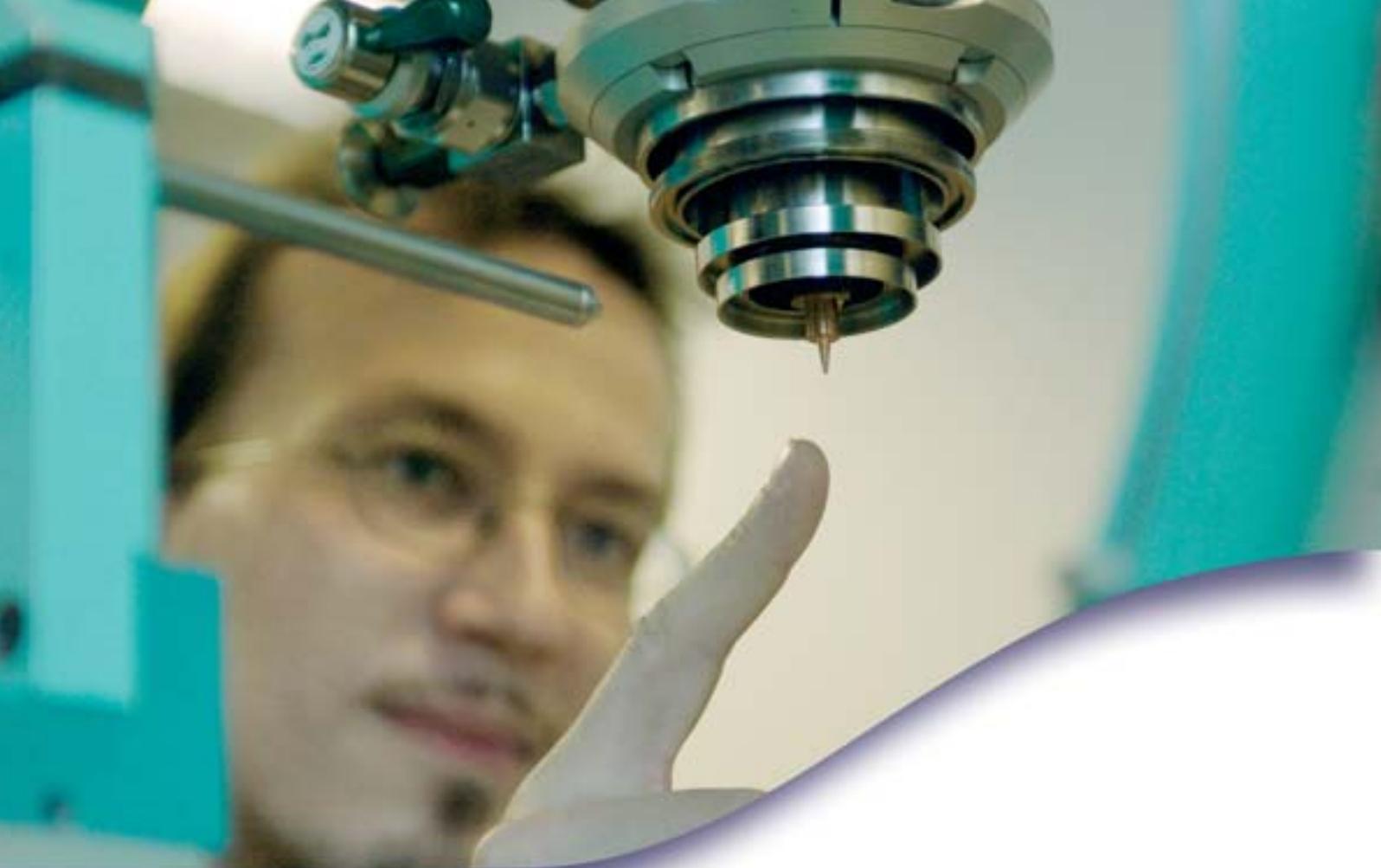
The construction work of the Kumpula campus continued during the year. Exactum was completed during the summer. The construction work on the Finnish Meteorological Institute and the Finnish Institute for Marine Research has proceeded according to the timetable. The planning of the building "Kumpula V" has made progress and an architect competition was begun in the end of the year. The building planned for the Faculty and campus administration, the university IT department, the Department of Geography, and the business incubators are expected to be completed during the year 2007.

The Physicum building, which promotes communality, has been used not only in the daily education and research and as a venue for international conferences and meetings, but also during common celebrations of the whole campus area. The Christmas party in the end of November gathered about 470 people belonging to different campus units. As a large and successful personnel party it strengthens the campus spirit.

Year 2004 was the last one in a six-year period, during which the research is going to be evaluated in the 2005 evaluation, which involves the whole University. The preparation for this evaluation can be seen in this Annual Report, since the statistical information is given for the years 1999 - 2004 and the policy changes in the research during the six years are described.

Juhani Keinonen

Professor, Chairman of the Department



Trends in research in 1999–2004

In the period 1999–2004 major changes have emerged in the research programme of the Department. The fusion of three separate departments in 2001, namely the Department of Physics, Department of Geophysics, and Department of Meteorology, and the relocation to a completely new building Physicum in the new Kumpula campus have strongly affected the activity of the Department. A significant improvement in the working environment was introduced in the new building by the modern laboratory premises. In the research profile of the Department the main areas are now the following ones: materials physics, condensed matter physics, applied physics, particle physics, atmospheric sciences, and geophysics.

The research profile of the Department has been changed along with the filling of the new professorships. This has been done according to the strategic planning during the past 10 years. Thirteen

new research areas have been included in the research programme and two were discontinued, namely molecular physics and experimental nuclear physics. The number of professorships has increased by 10 and there are now 27 professorships. Out of the 27 positions 20 have been filled during the past 10 years and 3 are still to be filled. Nine of the professorships are financed partly or totally by other organisations than the Department.

The 16 professorships filled in the six years period 1999–2004 are the following ones: in 1999 Risto Orava in experimental particle physics (new area), Heimo Saarikko in physics teachers' education, and Hannu Savijärvi in meteorology; in 2000 Markku Kulmala in environmental physics (temporarily in 1996 and permanently in 2000) (new area); in 2001 Lauri Pesonen in solid earth geophysics, Kari Enqvist in cosmology (new area), and Timo Vesala in meteorology; in 2002 Arto Annala in biophysics (new

area), Keijo Hämäläinen in experimental solid state physics, and Hannu Koskinen in space physics (temporarily in 1997 and permanently in 2002) (new area); in 2003 Aike Beckmann in oceanography geophysics (new area), Kaarle Hämeri in aerosol physics (new area), Kai Nordlund in computational physics (new area), and Jyrki Räisänen in accelerator based materials physics (new area); in 2004 Jyrki Kuikka in medical physics (new area) and Ritva Serimaa in experimental soft condensed matter physics (new area).

The positions to be filled in 2005 are in particle physics phenomenology (according to the decision by the University Senate, Katri Huitu will be invited) (new area), in cosmology, and in experimental meteorology (new area). There are two positions, which will be defined and filled in the near future.

The other professors of the Department are Masud Chaichian in theoretical high energy physics, Paul Hoyer in theoretical elementary particle physics, Keijo Kajantie in theoretical physics, Juhani Keinonen in applied physics, Matti Leppäranta in hydro-sphere geophysics, Dan Olof Riska in theoretical nuclear physics (on leave of absence since 2000, at present director of the Helsinki Institute of Physics). Professors retired in 1999–2004 are Pekka Suortti in condensed matter physics (2004), Folke Stenman in molecular physics (2003), Kari Eskola in experimental nuclear physics (2002), Timo Paakkari in solid state physics (2002), Mauri Luukkala in electronics (2002), Asko Anttila in accelerator based physics (2001), and Antti Siivola in physics (1999). Christofer Cronström in theoretical nuclear physics retired in the beginning of 2005.

According to the new structure of the jobs in the University, all the university lecturer posts are new positions. The university lecturers are: Tommy Ahlgren in materials physics (started in 2001), Marja Bister in meteorology (2002), Björn Fant in physics teaching in Swedish (originally senior assistant), Edward Haeggström in electronics (2002), Katri Huitu in particle physics phenomenology (2003), Ari Hämäläinen in teachers' education (2002), Esko Keski-Vakkuri in theoretical physics (2004), Ismo Koponen in physics teachers' education (2004), Hannu Kurki-Suonio in theoretical physics (cosmology and general relativity theory) (2001), Antti Kuronen in computational materials physics (2004), Kari Lehtinen in aerosol and environmental physics (2003), Seppo Manninen in solid state physics (originally lecturer), Jouni Niskanen in theoretical physics (2003), Eero Rauhala in accelerator based materials physics

(2001), Jouni Räisänen in meteorology (2003), Rami Vainio in space physics (2004), Kenneth Österberg in experimental particle physics (2002), and Ritva Serimaa in experimental solid state physics (2004); the last position is now open. All the university lecturer jobs are related to the research areas of the professorships. The positions are filled permanently after the filling of the professorships.

The trends in research have been developed in the following way:

Materials Physics and Related Applied Physics

In the **Division of X-ray Physics** major changes have taken place. The working environment improved significantly in 2001 when operations in the new building with modern laboratory premises started. Today, the versatile and upgraded x-ray instrumentation as well as our profound knowledge of radiation-matter interaction phenomena is unique and of increasing importance. This is evident from the expanding collaborations within national materials science community while at the same time the vivid high-profile international collaboration network utilizing synchrotron radiation is being strengthened.

Directing the research to new areas during the last few years has been partially due to the major changes in the scientific personnel. Professors Timo Paakkari and Pekka Suortti retired and the new generation of professors are taking the place. The structural studies of various materials are now well covered by the new professors, Keijo Hämäläinen (solid state physics), Ritva Serimaa (soft condensed matter physics) and Arto Annala (biophysics).

The hard condensed matter research and the associated teaching activities form the bulk of understanding the electronic structure that accounts for the macroscopic properties of materials. Inelastic x-ray scattering spectroscopy is widely utilized in fundamental studies of semiconductors, magnetic materials and superconductors, for instance. During the last few years the computational activities to support the synchrotron radiation experiments have significantly increased. Very recently a new research programme focusing on the structure and dynamics of liquid water was initiated.

Activities in the soft condensed matter research on weakly ordered materials, especially polymers, have been steadily increasing. The laboratory has a

small angle x-ray scattering instrumentation, unique in Finland, for most of in-house experiments. Obviously, a significant part of the experimental work is carried out at various synchrotron radiation facilities worldwide. Recent research programmes include, e.g. structural studies of fuel cells, catalytic materials and wood. Presently the activities are extending to nanotechnology and especially to bio-nanomaterials.

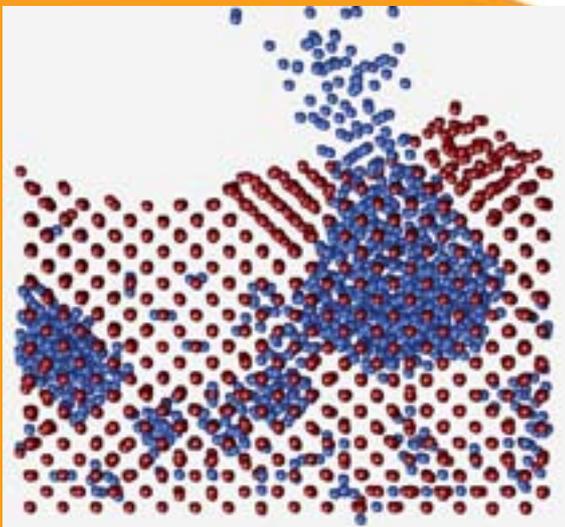
The new chair in biophysics is jointly funded by the Department of Biosciences and the Institute of Biotechnology. It has turned out to be timely and successful establishing a close collaboration with the biology community with numerous interesting problems requiring physical characterization methods. Biophysics is utilizing more and more the experimental soft condensed matter techniques available at the Division while the close collaboration with the Viikki campus offers complementary experimental techniques, such as NMR spectroscopy. Recent research programmes in biophysics include, for example the study of conformational changes in proteins and weakly structured polypeptides.

In addition to the aforementioned research areas, also activities in more applied areas have emerged during the last six years. In 1999 a new research programme on medical imaging utilizing synchrotron radiation in close collaboration with the ESRF and the Helsinki University Central Hospital was initiated. The programme is ongoing and shows potential for clinical applications. The other new applied research area is associated with space science

projects to make use of our expertise on detectors and x-ray spectroscopy.

In the **Accelerator Laboratory Division** several important changes have taken place. The research programme has been directed, to a growing extent, towards materials science and applied physics, while the nuclear and molecular spectroscopy studies have been ended. In this respect, entirely new research areas have been initiated partly based on new equipment. The main studied materials include several novel semiconductors, optoelectronics and carbon based materials. Nanoscience related research is gaining increased importance in the research programme. Computer simulations have been intensified to complement the experimental part of the research programme.

The research equipment has been significantly modified and altered. The old van de Graaff accelerator was dismantled in 2001. The tandem accelerator has been modified both to be a computer controlled facility and to meet the needs of accelerator mass spectroscopy. A new 500 kV accelerator was launched into operation in 2002. The low-energy accelerator for thin film deposition, constructed from the old isotope separator, and a nanocluster deposition system will become fully operational by the year 2005. This and other extensive construction work started in 2001 in the laboratory room called nanohall and will be finalized in 2006. This allows research work to be carried out in full strength taking advantage of, besides the cluster-beam deposition



facility, the low-energy ion deposition accelerator and various surface characterisation techniques. The atomic force microscope obtained in 1999 has proven to be extremely useful in materials research and it will be prominently used in the newly initiated nanocluster deposition based research.

The set-up, using the time-of-flight elastic recoil detection analysis (TOF-ERDA), has actively been used for the characterization of different samples and has been an important tool for the national collaboration in studies of optoelectronics materials and on the campus for studies of thin atomic layer deposition films. An important reason to develop the TOF-ERDA measurements and analysis has been the diamond-like carbon thin films, which have been studied to be used as the first wall material in the future fusion reactor ITER. The effects of deuterium concentration and ion-irradiation induced defects on the hydrogen migration and trapping have been investigated.

The activity in the computer simulations has expanded and evolved strongly. In 1998 the activities were mainly focused on molecular dynamics simulations of irradiation effects in elemental semiconductors and metals. Since then several new activities have been added to the research profile. In 1998 the molecular dynamics simulations were, for the first time in the literature, used to examine plasma-wall interactions in fusion reactor materials. This research line has proven so successful that now about ten other groups are following our lead. Around the same time, the examination of nanocluster deposition at surfaces was originated, a project which is closely linked to experimental developments in the laboratory. In 2000 the study on how ion irradiation can be used to modify the properties of carbon nanotubes was started. This research has produced a multitude of results, many of which were predictions of effects which have since then been experimentally confirmed by various groups working around the world.

The expansion has not only involved the range of systems studied, but also the complexity of the materials and the methods used. We have been actively involved in a collaboration to develop reactive interatomic potentials for alloys and compounds of technological interest. We have also taken into use models describing polymeric hydrocarbon systems. The method palette in our regular use has expanded from classical molecular dynamics to include also DFT electronic structure calculation methods, tight-binding molecular dynamics, as well as kinetic Monte Carlo to deal with long time scales.

The scientific computing has been strengthened in the Laboratory and Department by purchasing three computer clusters in 2001–2004, the first one consisting of 15 alpha computers, the second one 64 PC's coupled to work as a cluster, and finally a cluster of 130 PC's for GRID computing.

Professor Juhani Keinonen has continued and professors Jyrki Räisänen and Kai Nordlund have started their research in the Laboratory. Professor Asko Anttila who studied thin amorphous diamond films for medical applications retired in 2001. This research continued until 2004 when the studies were ended in the research programme of the Laboratory. Folke Stenman who studied molecular physics retired in 2003. Also this research line was ended in the research programme of the Laboratory.

Atmospheric Sciences

The **Division of Atmospheric Sciences** is a merger of the former Department of Meteorology and the Laboratory of Aerosol and Environmental Physics of the Department of Physics. The chair of space physics also belongs to the Division. The main research activities are divided into: (i) aerosol and environmental physics, (ii) micrometeorology and forest-atmosphere relations, (iii) dynamical and physical meteorology, and (iv) space physics. The growth of the Division is demonstrated by the increase of the researchers, which has doubled in the past six-year period. Also the number of international projects (e.g. EU-funded) has increased by a factor of seven during the last 6 years. During the last 6 years the staff members of the Division have received several international and national awards. From the beginning of August 2004 professor Kulmala has been appointed as Academy professor for the period 2004–2009.

The Division has the possession of: 1) a weather radar, 2) aerosol and micrometeorological instruments for field campaigns, and 3) a laboratory for research of aerosol microphysics, and three field stations.

The Division operates together with the Department of Forest Ecology at two field stations: the SMEAR II station (Station for Measuring Forest Ecosystem-Atmosphere Relations) in Hyytiälä in Central Finland, and the SMEAR I station in Värriö in southern Lapland. In 2004 the new measurements station SMEAR III (urban SMEAR) has been constructed in

the Kumpula Campus area. This will be operated in collaboration with the Finnish Meteorological Institute (FMI) of the Ministry of Transport and Communications.

During 2004 the development and construction of new weather radar has been performed in collaboration with the Finnish company, Vaisala Oyj.

The Division has great experience in numerical modelling of the atmosphere (e.g. improving radiation schemes for General Circulation Models; a mesoscale model with wide applications for Earth and Mars), and in micrometeorological flux and aerosol formation studies.

Professor Savijärvi's group of atmospheric modelling has introduced novel radiative transfer parameterization methods, which are used, e.g. in the HIRLAM, ECMWF, and Rossby Centre models. His group develops and applies the University of Helsinki mesoscale model, e.g. in the tropics as well as in the arctic. This small group is a world leader in applying its boundary layer and mesoscale models on planet Mars, and a version of HIRLAM is now available for the Marsian atmosphere.

The aerosol and micrometeorological groups of the Division belong to the Research Unit on "Physics, Chemistry and Biology of Atmospheric Composition and Climate Change" (coordinator prof. Markku Kulmala), which is one of the Centres of Excellence of the Academy of Finland. The main objective of the Unit is to study the importance of aerosol particles on climate change and on human health. The centre of excellence status is a recent one (for the period 2002–2007).

Internationally, the CoE unit has received a leading position in the research area of formation of fresh atmospheric aerosols. Our approach has started from basic nucleation theories followed by detailed aerosol dynamic/atmospheric chemistry models and well defined laboratory experiments and has ended to wide continuous field measurements in our research stations and to 3D modelling. We have also a leading position in the research area of micrometeorological fluxes of aerosol particles and their precursors. We have a unique possibility to study biosphere-aerosol-cloud-climate interactions, since the team is very interdisciplinary. Satellite data is also used together with point measurements and 3D-models. Scientists involved in our research unit are key figures in international scientific organisations and networks such as ICCP, IGAC/IGBP and iLEAPS/IGBP. (iLEAPS, see p. 36, Laboratory Overviews, Division of Atmospheric Sciences.) Based on our scientific activities, our member teams in Helsinki have been elected as a host for the International project office of iLEAPS/IGBP.

The aerosol group belongs (since 2003) to Nordic Centre of Excellence "Biosphere-Aerosol-Cloud-Climate Interactions" (coordinator professor Markku Kulmala) and the micrometeorology group to the Nordic Centre of Excellence "Nordic Centre for studies of ecosystem Carbon exchange and interactions with a Climate system" (coordinator A. Lindroth, Lund University, national team leader prof. Timo Vesala). Both groups belong also to NorFA Graduate School "Carbon-Biosphere-Aerosol-Cloud-Climate Interactions" (coordinator Markku Kulmala).

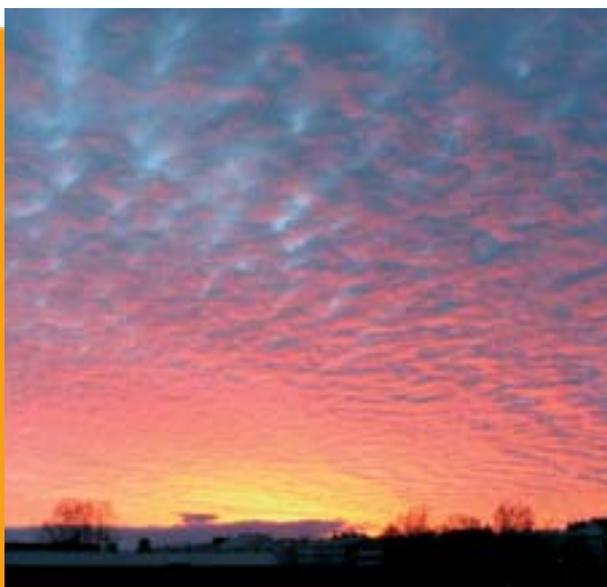


Photo: Oona Loman

The main innovations during the last six years have been the following ones: (i) relevant formation routes of atmospheric aerosols, including different nucleation and growth mechanisms and the effect of biogenic vapours on aerosol formation, (ii) observation of new particle formation and subsequent growth in the atmospheric boundary layer; for example in Hyytiälä (SMEAR II station) 80–100 particle formation events are observed each year; (iii) formation and growth of cloud droplets and their contribution to climate change, (iv) measurements and interpretations of atmospheric aerosol and trace gas fluxes, (v) hygroscopicity and composition of nucleation mode particles (diameter < 20 nm) with continuous *in situ* techniques, (vi) continuous measurements of atmospheric and ecological mass fluxes and aerosol precursors and CO₂/aerosol interaction in the SMEAR stations, (vii) phase transitions in aerosols, (viii) UV-induced NO_x emissions, (ix) development of basic nucleation theories based on molecular dynamics and Monte Carlo simulations as well as a density functional approach and classical thermodynamics, and (x) development of aerosol dynamic codes to investigate formation and growth of aerosol particles, especially organic aerosols.

Medical Physics and Biophysics

In medical physics the main research areas from 1999 to 2004 have been boron neutron capture therapy (BNCT) and medical imaging applications.

The EU project on BNCT dosimetry was completed in 2003. A Report of Recommendations for the Dosimetry of BNCT has been sent for a review process worldwide for the specialists in the field. The project was organized within the EU 4th framework programme of Standards, Measurements and Testing and was sponsored by the European commission. The research group has had an essential impact both in the theoretical and experimental part of the research project carried out from 1998 to 2003 with eleven European partners including three Finnish partners (University of Helsinki, Radiation and Nuclear Safety Authority of Finland and Technical Research Centre of Finland).

Intracranial BNCT treatment in two protocols continues and a new protocol for recurrent head and neck tumours has recently been started. For improved treatment planning in BNCT it is beneficial if *in vivo* ¹⁰B-distribution in the target area could be

determined. Currently we are studying the possibilities to use ¹H spectroscopy imaging in ¹⁰B-distribution determination.

Methods were developed for fusion of MR (magnetic resonance) and SPECT (single photon emission computed tomography) images and MEG (magnetoencephalography) data, the main application being the diagnosis and treatment of epilepsy. Combined MR imaging, transcranial magnetic stimulation (TMS) and EEG techniques have been applied to study the neuronal connectivity of the healthy human brain. In the head and neck BNCT, image fusion was used to co-registrate PET (positron emission tomography), CT (computerized tomography) and MR images for treatment planning. Pre- and post-treatment MR images were fused to study the pattern of glioblastoma recurrence in patients treated with BNCT.

The studies in biophysics are described in the trends of the X-ray Laboratory Division.

Particle, Mathematical and Nuclear Physics

Over several years the main topics of research at the **Division of Theoretical Physics** have been particle cosmology, theory and phenomenology of hot and dense quark-gluon plasma, mathematical physics and the physics of hadrons.

The first general idea underlying the research is that it has to be connected with intensive experimental or observational efforts under way: in cosmology satellite observations have given remarkably quantitative information on the universe, in the physics of relativistic heavy ion collisions remarkably accurate data has been obtained at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven. The outlook for the future is very promising, too: new satellites will be launched and CERN LHC will be producing data in 2007

The second general idea is the unity of physical ideas: various physical theories form a tower of coarse grained descriptions of Nature, each valid at a particular energy scale. Therefore similar methods can be applied to physical problems ranging from early cosmology and string theory to properties of quark-gluon plasma and hadrons and finally to properties of condensed matter systems. The common denominators of the effective theories employed are quantum and statistical physics, with an emphasis on computational methods, both purely numerical and symbolic.

During the period 1999–2004 cosmology has undergone a remarkable transformation to a precision science. The cosmology group has studied several properties of the observed primordial density fluctuations and used them to constrain possible beyond-the-standard model theories, mainly in the framework of the inflationary paradigm. For example, several particle motivated theories predict subdominant isocurvature fluctuations that typically are correlated with the adiabatic fluctuations as well as small non-gaussianities.

As a preparation for future observations, the cosmology group has developed a long-term active participation in the European Planck satellite project. It forms a significant part of the CTP working group, which is trying to establish ways to estimate the temperature and polarization spectra of the microwave background radiation. The activity has so far centred on algorithms and codes for making full-sky maps of the temperature and polarization of the microwave background.

In heavy ion collision physics the group has developed an own saturation model for particle production in relativistic nuclear collisions and, in a much cited work, predicted correctly various experimental results from RHIC experiments.

Parallel to this phenomenological work first-principle methods, both analytic and numerical, of quantum chromodynamics have been further developed. The grand project has been the computation of the most fundamental quantity of hot quark-gluon plasma, its free energy. It is remarkable in that its perturbative expansion, which due to asymptotic freedom could be expected to be very accurate at very high temperature, actually at sixth order contains a non-perturbative term, which can only be computed numerically. It has been a long-standing problem how this computation should be organised. The group has finally solved this by formulating a precise set-up, by performing several very difficult required intermediate analytic and numerical steps and by defining precisely what still has to be done: one extremely demanding but feasible analytic computation and one numerical computation. Both are under way.

The **High Energy Physics Division** theory group has worked in areas of basic research and related to experiment topics, covering Quantum Field Theory, Noncommutative Geometry, Gauge and String Theories, Higher-Dimensional Theories, QCD and Particle Phenomenology. The group has achieved in

1999–2004 remarkable results internationally well known. The main research lines of the theory group are:

The quantum nature of space-time is one of the fundamental questions and hence the study of Quantum Field Theory on noncommutative (NC) space-time has been topical during the recent years. Important issues, unitarity, causality, spin-statistics and CPT theorems have been investigated by the group and pioneering steps were made in obtaining exact results and in an axiomatic formulation of NC QFT, leading to a rigorous derivation of the Froissart high-energy bound on total cross-section also for such theories. A breakthrough of the group, namely the discovery that NC QFT are invariant under the twisted Poincaré symmetry, amounts to a new formulation of relativity theory for quantum space-time as compared with the special relativity. In phenomenological implications, a NC version of the Standard Model has been constructed, based on a no-go theorem for NC gauge theories, which bears the name of the Helsinki group. Also, one of the strongest bounds on the NC parameter has been obtained by calculating for the first time the Lamb shift in NC QED.

Research in string theory was mainly focused on the AdS/CFT correspondence, the dual equivalence between supersymmetric gauge and string theories, important for constructing an ultimate unified model of the four fundamental interactions. The group has investigated the holographic anomaly of a supersymmetric gauge theory and has proven that the AdS₅/CFT₄ correspondence indeed holds.

Higher-dimensional theories are another main theme of the group. The important problem of strong CP was considered in such models and found to be absent. A modified Kaluza-Klein reduction with the correct orbifold compactification has been proposed by the group, leading to new implications in particle physics, astrophysics and cosmology and providing significant modifications to collider phenomenology of extra dimensions. The group has also proposed a mechanism for the fundamental problem of colour confinement as a consequence of asymptotic freedom and compared with that of other models based on an analogy with type II superconductor. This is a new description of confinement problem purely within QFT, in contrast with other approaches which involve supersymmetry and string theory.

Another line of research has been the study of hadron physics on the basis of QCD, mainly using perturbation theory as a guide. Among the princi-

pal topics are: i) the systematics of quarkonium production, which is sensitive to the environment in which the heavy quarks are produced; ii) the dynamics of hard scattering in QCD; iii) studies of the effects of the non-trivial QCD ground state on quark and gluon propagation.

On particle physics phenomenology, the focus of research of the group in beyond-the-Standard-Model has been on supersymmetric and higher-dimensional models with important results on the breaking mechanism of supersymmetry. Implications of several different breaking methods have been investigated. Proposals crucial to improve, e.g. the anomaly mediated supersymmetry breaking have been made. In addition, conservation of R-parity will determine the signatures of supersymmetry at colliders. Constraints on R-parity breaking couplings and signatures of the breaking have been studied. Possible manifestations at colliders have been investigated and specifically complications in different theories in searching the Higgs boson have been studied which are important for coming collider experiments.

The Experimental High Energy Physics group has been expanding its research activities in the field of QCD and experimental tests of the Standard Model. The study of gluons and the heaviest quarks are the cornerstones of the experience built up through the past several years. In addition to the software and analysis tools, the group has developed innovative high precision gas amplified and room temperature semiconductor detectors.

The experimental activities related to the DELPHI experiment at CERN's LEP collider are in the process of being finalised as we look forward to the coming era of the CERN LHC collider. The in-depth expertise, both in the construction and operation of the DELPHI Hadron Calorimeter (HCAL) and Micro-Vertex Detector (MVX), in combination with heavy quark tagging algorithms will provide an excellent basis for group's contributions in the LHC physics programme.

The study of colour coherence in QCD, the experimental observation of the dead-cone effect, the determination of the quark mixing matrix element $|V_{ub}|$, and the search for new particles like charged Higgs bosons, predicted by many extensions of the Standard Model, can be considered as the highlights of the LEP programme. After dismantling the CERN LEP collider and its experiments in 2001, the group

focuses on active physics analysis at Fermilab and on preparations for an active physics programme for the LHC-TOTEM experiment. On the basis of its reputation built at LEP, the group was recently accepted to join the CDF experiment at the Fermilab Tevatron antiproton-proton collider. The group analyzes the properties of the top quark in detail and, in particular, is developing novel ways to measure the top quark mass with high precision. Also in CDF we apply our past experience in the operation of the DELPHI Silicon Vertex Detector to our new engagements in the operation and performance studies of the upgraded vertex detector of the CDF. Tevatron poses a challenge to the current computing and data handling technologies, lending itself as an ideal test bed for global distributed computing, better known as GRID technologies. Close collaboration with the Rovaniemi Polytechnic Institute and collaboration within the European Research Training Network (EU-RTN) are ongoing to study this aspect.

The activities related to the physics planning, design and construction of the TOTEM experiment at the LHC collider, offer a direct continuation of the group's efforts at LEP and at the Tevatron. The group has gained the coordinating role in both physics analysis studies and construction of key parts of the experiment, focussing both on diffractive physics and central diffractive Higgs production and the development of Gas Electron Multiplier (GEM) detectors for the T2 tracking station. In addition, the group has made important new innovations in the field of 3D silicon detector structures in cooperation with the State Research Centre (VTT).

The development of new and innovative radiation detectors serves both the experimental programmes at CERN and Fermilab and fields beyond, such as medical imaging, X-ray astronomy and nuclear fusion diagnostic instruments. A large expertise has been built up in the development of Gas Electron Multipliers (GEMs) and the phenomenon of ageing in gaseous radiation detectors. Simulation studies of the newly developed 3D silicon structures have revealed remarkable properties, such as ultra-fast charge collection time, radiation hardness and near edgeless sensitivity of the physical sensor to be exploited as very forward detectors within Roman pots at the LHC. These technologies have an intimate connection to the aims and tools applied in nanotechnology based R&D.

Geophysics

In the developments within the **Division of Geophysics**, the past six years have been a period of changes. After being an independent department, the Geophysics unit became in 2001 a Division in the Department of Physical Sciences. After retirement of two professors, two new ones were nominated (Lauri Pesonen for the solid earth geophysics and Aike Beckmann for the hydrosphere geophysics). All these resulted in major changes in the scope of research of hydrosphere and solid earth geophysics.

Many of the research themes of the Division are global in their nature and relevant for the society. These include the study of global changes, the geophysics of snow and ice, marine and limnological research and lithosphere studies. New topics added to the programme since 2001 include environmental geophysics, geophysics laboratory works, magnetic and gravity modelling, courses in marine science and ocean modelling. The hydrosphere geophysics field courses (summer and winter) have been a vital part of the geophysics research and education. These have been carried out at the University of Helsinki field stations in Lammi, Tvärminne and Kilpisjärvi.

In solid earth geophysics, the main activities concentrate on Precambrian supercontinents, meteorite impact structures, geomagnetic field studies and meteorite petrophysics. Innovations since 2001 include a construction of a new research laboratory

for solid earth geophysics, which is fully equipped for high-resolution rock magnetic, paleomagnetic and petrophysics research featuring a new generation superconducting SQUID magnetometer, a Vibrating Sample magnetometer and a Curie-balance. The solid earth geophysics branch has contributed significantly to our knowledge on properties of the past geomagnetic field and impact processes. Finland has now eleven confirmed meteorite impact structures; three of them were discovered in the last six years. More recent additions include the study of deep continental drillcores, the role of impact effects on the Earth's biosphere (biogeophysics), the study of the meteorite-asteroid links and participation in the sample-return programmes.

In the hydrosphere section, the main research line has been snow and ice geophysics. Basic research and modelling of sea ice dynamics has been carried out in polar and sub-polar freezing seas. New results have been obtained in the scaling and fine resolution modelling. The snow research group has investigated the snow cover structure and its properties in Finland, Svalbard and Antarctica, for example producing the first snow classification scheme for Finland. Lake ice cover has been worked on for the seasonal cycle, with new results for spring melting period. As part of the snow and ice work, close collaboration has been opened with winter ecological research groups in the Faculty of Biosciences.

In the summer season investigations, the weight has been in optics of natural waters and



Measuring the physical properties of surface snow in Antarctica.

Photo: FINNARP

water quality. Field campaigns have been performed in North-European waters, and the first optical classification for Finnish lakes has been prepared. Algorithms have been developed to extract information of optically active substances from remote sensing data. In water quality research, new innovations have been made for mapping methods, producing a technological prize and the birth of a private geophysical company.

The new (since 2003) ocean-modelling group is participating in a multinational effort to model the global ice-ocean system, designed to evaluate and improve the tool for climate variability and climate change research. Numerical process studies are being used increasingly as an advanced and powerful research method for a variety of environmental topics, e.g. physical-biological interactions in aquatic systems, or the thermodynamics and dynamics of supraglacial lakes in Antarctica.

Space Physics

Physical phenomena in space, either far or near, have always belonged to research topics in physics. The modern research environment at the Department of Physical Sciences has gradually grown along three independent lines: 1) Solar system plasma physics in close collaboration with the Finnish Meteorological Institute (FMI), 2) Cosmology related to elementary particle physics, and 3) Detector development for high-energy astrophysics instruments. With the inclusion of meteorology and geophysics into the joint Department in 2001, also planetary meteorology and geophysical studies of meteorite impacts were added to the activities of the newly formed Space Research Unit (SRU) of the Department. The unit is an internal umbrella organisation to support and coordinate practical research and teaching activities at several (presently five) Divisions of the Department.

In 1997 a professor position in space physics was created jointly with the FMI and it became permanent in 2002. Hannu Koskinen has all the time held the position. The research activities are focused on solar system plasma physics. Research is to a large extent conducted in close collaboration with the space research projects of FMI. Also most of the post-graduate students are employed at the FMI.

The cosmology group is at present the largest space group of the SRU (about 8 person years of work in 2004). In 1998 the previously pure theory

group became involved in the Planck cosmic microwave background mission of ESA (European Space Agency) and presently they are active in the extensive data analysis development for the mission to be launched in 2007.

Instrument participation in high-energy astrophysics missions started with the Russian Spectrum-X-Gamma mission in 1997. The Division of X-ray Physics participated in the development of the silicon X-ray array development and fulfilled its work although the satellite was never completed in Russia. The next project started in 1999. It was the solar X-ray monitor (XSM) onboard ESA's SMART-1 spacecraft to the Moon (launched in 2004). The joint Detector Laboratory of the Department of Physical Sciences and the Helsinki Institute of Physics (HIP) has had a significant role in the instrument development within the Antares programme during 2001–2004.

Planetary meteorology is presently focusing on Mars, as described in the section Atmospheric Sciences.

A major boost to space research of the Department of Physical Sciences was the national research programme, Antares, funded by the Academy of Finland and the National Technology Agency, Tekes. The Department had a leading role in three Antares consortia: the scientific activities of the consortium participating in ESA's Planck satellite mission were led by professor Kari Enqvist, the space weather research consortium by professor Hannu Koskinen and the consortium to study small-scale weather phenomena on Mars by professor Hannu Savijärvi. Furthermore, the Division of X-ray Physics and the Detector Laboratory had significant participation in the high-energy astrophysics consortium. While this programme really lifted the volume of space research of the Department to an impressive level, it also led to a strong dependence on external funding (69% in 2002).

In 2005 the Kumpula Campus will become the largest and strongest space research environment in Finland, as the FMI will move to the Campus. For this purpose the Department of Physical Sciences and FMI will establish a joint Kumpula Space Centre. It will strengthen the existing co-operation within space physics and also contribute to FMI's space-based remote sensing activities. The mission of the Space Centre will be based on research projects of the University and FMI and it will also provide technological and programmatic support to space instrument development and operations as well as data reception and processing.



Vice-Rector Hannele Niemi presented the awards for the good quality of education on the 1st of December .

Photo: Seppo Andersson

Education

BASIC EDUCATION

In the Department of Physical Sciences, education is given in physics, theoretical physics, geophysics and meteorology. The basic education in physics is also given in Swedish. The education of physics teachers also belongs to the traditional main tasks of the Department. This includes both education for the Master's degree and further education programs for physics teachers and general teachers specializing in physics.

The educational program of the Department is more diverse than that of any other department of physical sciences in the Finnish universities. The total number of lecture courses given yearly is about 160, 15 of which are given in Swedish and about 15 in English.

The quota of new students in physical sciences, approved by the Senate was 160. There were 406 applicants of whom 151 have started their studies in 2004. Thirteen of those entered the physics teacher line. The

entrance examination was organized together with the universities of Jyväskylä, Oulu and Turku.

Summer schools and field courses

The theme of the 2004 summer school for research-oriented physics students was biophysics. It was organized by professor Arto Annala, from May 31st to June 2nd . A score of young students from the first to the 4th year of studies attended the summer school, held in Finnish.

The emphasis of the summer school was on modelling and measurement of systems formed by biological molecules. During the last few years there has been notable progress in research on the structure and modelling of biological macromolecules and molecular complexes formed by them. In addition to a general review of the topic, computational methods and algorithms were treated in a more detailed way in the lectures.

The summer school was organized in the Kiljava Institute in Nurmijärvi, located on a naturally beautiful pine tree moor on the beach of the Sääksjärvi-lake with crystal clear water, only about a 45 min drive from Helsinki. As usual, time was reserved also for leisure time and togetherness in this splendid milieu.

A solid earth geophysics field course was organized in Kerkkoo, SW Finland. The course was a co-operation with the Helsinki University of Technology, the Geological Survey of Finland and the Institute of Seismology of the University of Helsinki. Gravity, seismic, magnetic, electromagnetic, IP and ground penetrating radar surveys were exercised in the field with students. New petrophysical hand samples were taken by assistant Fabio Donadini and Professor Lauri Pesonen in order to model geophysical data.

Evaluation of teaching

Student critique of lecture courses and other teaching was started in collaboration with the Faculty during the spring term 1995 and has been continued since then. A web-based questionnaire is in use in the Department so that students can send comments during each course. This gives rapid feedback to the teachers and encourages students to take part in the development of the teaching in the Department. However, at the end of the "biggest" courses students are also given a questionnaire on paper because it has been observed that more feedback will be obtained with this traditional method. The feedback is presented to the departmental board.

In order to increase the interest of the personnel in education "the best teacher" chosen by the students has been given a prize since 1994. In 2004 the physics student society Resonanssi ry arranged the voting via e-mail. As a few years earlier, the students proclaimed professor Matti Leppäranta the best physics lecturer of the year whilst also extending a letter of distinction to MSc Ossi Pasanen.

INTERNATIONAL STUDENT EXCHANGE

Physics is very international by nature. In addition to this, the Department of Physical Sciences has an active international student and teacher exchange programme involving Erasmus/Socrates agreements and Nordplus collaboration with over twenty insti-

tutions around Europe. Over the years 70 of our students have utilized these possibilities.

To support internationalization also at home the Department offers a wide selection of teaching in English, of which most popular among foreigners have been various theoretical and environmental physics courses. In fact, most advanced courses in the Department can be taken in English when necessary. A total of about 1500 study weeks (about 2200 ECTS credits) were obtained from courses given in English during 2004.

The number of incoming exchange students has stabilized at about a dozen. In addition, there were also still many more foreigners following courses and working in individual research groups and the Helsinki Institute of Physics, HIP. Quite a few of the visiting or exchange students have applied and remained as degree students testifying the high quality of teaching as perceived by the students. Some also want to return to Helsinki after their degree in the home university to pursue graduate research here.

Another channel of internationalization for students is afforded by CERN summer trainee positions. Three students from the Department were able to take this opportunity to gain international laboratory experience. Short international intensive courses are regularly arranged by the department and attended by foreign as well as domestic students. Further, research groups may send advanced or graduate students abroad for short-term research or conference trips. Also foreign researchers working at the Department or HIP (Helsinki Institute of Physics) gave short courses on special topics

POST-GRADUATE EDUCATION

The Department is responsible for post-graduate training in physics, theoretical physics, particle physics and in physics teacher training, jointly with the Department of Applied Sciences of Education.

Its size and extensive research activity enable the Department to offer an effective post-graduate training program. On the basis of the number of post-graduate degrees our Department is in the top rank in Finland. The collaboration in post-graduate education with the HIP and with the Helsinki University of Technology has a long tradition. International co-operation is pursued actively, and is seen as an essential element of post-graduate education.

In order to support and promote doctoral education the new "research education program" has been continued in the Department. In 2004 19 undergraduate students with a doctoral perspective were chosen. The total number of students in this program now exceeds 150. First PhD's graduated in 2001.

The nationwide researcher education programs (Graduate School, GS programs), which commenced at the beginning of 1995, form an effective platform for realizing post-graduate education. The Department is along in four nationwide programs: Materials physics GS (six persons), Particle and nuclear physics GS (three persons), Graduate School in Astronomy and Space Physics (one person), Graduate School in Informational and Structural Biology (one person) and additionally one person in the University of Helsinki Graduate School.

The progress of the studies and research work of post-graduate students were encouraged by employing the most successful students in research groups, and assistantships which have become vacant.

Lists of the students who completed their Lic. Phil. and PhD theses in 2004 in the Department are given in the Appendix.

ADULT EDUCATION

Great attention is given to the directives and plans of the controlling bodies in the University and of national education programmes. The functions and roles of physics in our society have become increasingly more important topics in contacts with schools, sixth forms and colleges, in order to ensure good student orientation prior to application for admission.

During several decades the Department has arranged a weeklong supplementary course fulfilling the requirements of the employment criteria for teachers at lower and upper secondary schools. This is noteworthy even nationwide. During the last few years a large number of teachers from the present colleges of advanced education have participated in these courses. Mainly teachers from the Department of Physical Sciences have been the educators. The popularity of the course shows that such education is needed, so the procedure will be continued with an annually changing topic. In 2004, Materials Physics was the theme of the course, which was attended by 29 teachers. Sixteen of the participants were women. The teachers came from lower and upper secondary schools, institutes of technology and polytechnics.



Photo: Seppo Andersson



Notability and Outreach

In an information society, education in physics and physics research form an important part of national development policy. As a country of high technology Finland has overtaken many of its competitors and research in physics, the basis of technology, is very active.

Alumni

Over the last three decades the Department has educated more than a thousand alumni. Each year our contactable alumni have received a copy of our illustrated and broadly informative Annual Report. Some form of contact has been upheld in recent years with almost 400 doctors (PhD), over one hundred licentiates of philosophy (Lic. Phil.) and about 500 graduates with a master's degree (MSc). The Department has been interested in the evolving activities of alumni

and the services rendered in society following their periods of physics education, the effort of earlier years in their Alma Mater.

Most of our alumni are serving society in the public sector. For doctors, licentiates and masters the figures are 87%, 78%, and 84%, respectively, in Finland. Abroad, all doctors (59 persons) except one and all the licentiates are in public positions whereas 20% of the masters are working in private enterprises.

The education received by physicists, meteorologists and geophysicists gives wide possibilities in choosing a field of activity. This is understandable considering the nature of physics as a science; it has described natural phenomena and their properties accurately and so predicted new phenomena. Education in physics trains the mind to seek out essential elements, construct possible models and gives courage to suggest reasoned predictions. High technology in Finland is based on the increasing understand-

ing of the foundations of the laws of physics. Logic, clear thinking and modelling leading to correct conclusions are needed in many tasks in modern society. On this view it is not surprising that our alumni are involved in a great variety of tasks and duties.

The information, which follows, is based on the activities of about 800 alumni graduated during the past 30 years in such a way that in the case of a particular alumnus only the highest graduate level has been taken into consideration.

Of those having a doctor's degree from our Department 265 are serving society in public tasks and 40 in private enterprises in Finland. Sixty doctors are known to work abroad, all but one in public tasks.

The Department's alumni hold or have held until recent years, almost 100 professorships, four of them in foreign universities. Among these alumni there are professors in leading positions in important research institutes and industrial enterprises. About 30 other doctoral alumni of ours are in other types of leading position. Many doctors (14) and some licentiates (2) function as university teachers in positions of university lecturers or adjunct professors (Docents). Our doctors have also taken over 20 positions in important teaching in polytechnics, as have 5 licentiates and 10 masters.

There are also those of our masters or licentiates who have taken a doctor's degree in another field and have obtained a position as a professor or director, in many cases abroad.

About 30 PhD's, 9 licentiates and 26 masters are in high leading positions in various kinds of institutions in Finland, with three masters abroad, repre-

senting 8% and 10% of our sample, respectively, and in the case of masters over 5%.

Over one hundred doctors serve as expert researchers in the fields of both experimental and theoretical physics, geophysics and meteorology in domestic universities or research institutes and about 40 abroad. About 150 masters are in research work with the aim of presenting their PhD theses.

Our Department has trained twelve doctors who work or have worked as leading hospital physicists, two in foreign hospitals, and the same number of MSc's working as hospital physicists.

Many of our alumni are serving the society as teachers of physics in schools and colleges. It is noticeable that in many schools the rectorship is in the hands of a physics teacher.

Our alumni are found in other kinds of academic tasks, such as science librarians, as experts in various fields, even inventors. Information technology science has tens of our doctors both in Finland and abroad, likewise several licentiates and masters. About 25 doctors and equally many masters and 11 licentiates function as civil servants, 2 doctors even abroad.

Several alumni, 9 doctors, one licentiate and 13 masters, are directors in firms. Many of our doctors are in research and development divisions of important firms.

Over 20 of our alumni have founded a firm of their own and are thriving well. Our education gives a firm basis for those few alumni who have become researchers in other fields, such as medicine; some alumni have, after their doctoral or master's thesis



in physics, studied to become a medical doctor and at least one master has become a dentist.

Industry has employed our doctors (5 domestically, 1 abroad), licentiates (5) and masters (15). Some masters and doctors have made their career in ministries (Ministry of Defence and Ministry of Trade and Industry).

There is almost 100% employment among our alumni. In 2004 it seemed that there was maybe one doctor between employments, and also two licentiates and three masters. In some cases the skills learned are being passed forward in the family milieu.

Expert services

The Department's researchers had leading positions in 113 international scientific organizations and in 29 domestic ones. These can be found in the Helsinki University Data Base (<http://www-db.helsinki.fi/muti/>).

The Department's researchers had 26 positions on the editorial boards of foreign scientific journals and six on the boards of domestic scientific journals. The researchers of our Department had altogether 135 refereeing positions in international scientific journals. One scientist had the position of editor-in-chief of a domestic journal.

People from our staff functioned as experts in 11 domestic boards, committees and other public bodies outside the University and in six international ones.

The researchers of the Department have often been invited to give interviews or lectures of public interest both for the "wide public" in happenings around Finland, on the radio and in TV programs. Detailed information on these can be found at <http://www-db.helsinki.fi/yhti/>. Altogether they were along in over 90 such happenings.

Awards and Honours

The International Aerosol Research Assembly where all the greatest national societies in the field are presented has awarded Academy professor Markku Kulmala a very renowned prize, the International Aerosol Fellow Award 2004. Professor Kulmala got the recognition for his notable contribution in aerosol research. His research group has arisen to be the leading research group in this field in the world. The Prize is given out every two years.

Professor Kaarle Hämeri received a Nordic recognition prize from NOSA, the Nordic Society for Aerosol Research. The society has wished to draw attention to professor Hämeri's constancy of purpose in promoting Nordic aerosol research and his achievements especially in the fields of aerosols of the atmosphere and indoor air. The prize was awarded on the 11th of November in Stockholm in an aerosol research symposium.

Professor Timo Vesala was awarded the 2004 Norbert Gerbier-MUMM International Award for the scientific article on "Environmental controls over carbon dioxide and water vapor exchange of terrestrial vegetation". The article was published in the journal *Agricultural and Forest Meteorology* in 2002 (Vol. 113, pp. 97-120) with an international research group (B.E. Law, E. Falge, L. Gu, D.D. Baldocchi, P. Bakwin, P. Berbigier, K. Davis, A.J. Dolman, M. Falk, J.D. Fuentes, A. Goldstein, A. Granier, A. Grelle, D. Hollinger, I.A. Janssens, P. Jarvis, N.O. Jensen, G. Katul, Y. Mahli, G. Matteucci, T. Meyers, R. Monson, W. Munger, W. Oechel, R. Olson, K. Pilegaard, K.T. Paw U, H. Thorgeirsson, R. Valentini, S. Verma, T. Vesala, K. Wilson, S. Wofsy). The purpose of the Norbert Gerbier - MUMM International Award is to encourage and reward annually an original scientific paper on the influence of meteorology in a particular field of the physical, natural or human sciences, or on the influence of one of these sciences on meteorology. The award aims at stimulating interest in such research, in support of World Meteorological Organization WMO programmes. WMO is a United Nations Specialized Agency, working together in weather, climate and water. The prize has been founded in 1987.

On the 27th of April, Tuula Haatainen, the Finnish Minister of Education awarded in Helsinki eight National Prizes for Promoting Knowledge (Valtion tiedonjulkistamispalkinto), each 8500 euros, for persons or groups. Professor Kari Enqvist received one of these prizes for his book "Kosmoksen hahmo". In his book professor Enqvist shows how his field of science, cosmology, has during decades changed from philosophical speculation into an exact science based on scientific research.

The Rector of the University rewarded six University Units with performance bonus for the quality of education. The Department of Physical Sciences was awarded a prize of 23,000 euros for its good level of education.

Visits

On the 9th of January 2004, two Japanese professors, Ass. Prof. Hisaki Hitomi (Utsunomiya University, Faculty of Education) and Ass. Prof. Naoki T. Kuramoto (Admission Research Center of Tohoku University), with their guide from the Japonic-Finn Service, visited the Department. The visitors were in Finland in order to become familiar with the education of teachers of exact natural sciences. In our Department they were informed about physics teacher education and visited the teacher education laboratory, where Dr. Ari Hämäläinen showed a demonstration based on a computer guided measurement system. Professor Kuramoto was also especially interested in the entrance examinations in physics. MSc Terhi Mäntylä was the hostess of this delegation.

The Environment Committee of the Parliament of Finland visited Physicum on the 21st of April. In their program was a talk given by professor Markku Kulmala about the Interactions of the Biosphere and the Atmosphere.

The Cultural Minister of Argentina, Dr. Tulio Del Bono, escorted by other members of the Argentinian delegation and Embassy employees visited Physicum and the Accelerator Laboratory on the 21st of April. The other members of the delegation were Dr. Eduardo Charreau, President of the National Council of Scientific and Technical Research, Dr Oscar Tangelson, Vice Minister of Economy, Ing. Agr. Agueda Menvielle, Directress of International Affairs, Dr. Hugo De Vido, Secretary of the Federal Council of

Science and Technology, and Dr Alberto Ricardo Dibbern, President of the National University of La Plata. Professors Juhani Keinonen, Markku Kulmala and Timo Vesala hosted their visit.

Children's technology camp

The children's technology camp took place in the week 31.5. – 4.6. in Physicum for the fourth time. It was organized for the first time by the Department. In earlier years the Industrial Information Agency owned by the Confederation of Finnish Industries and Employers had been the organizer. 14 boys and 5 girls, aged 8 to 13 years, participated the camp. The themes of the camp were electricity, magnetism, mechanics, and optics. The participants paid also short visits to various Divisions of our Department where they were given information about research in a way suitable for their age. Again, the feedback from the participants and their parents was very positive.

Outreach to schools

Every year an invitation by letter to visit the Department is extended to physics teachers and their pupils of Finland's 504 sixth forms. Tens of classes of sixth form pupils visit the Department of Physical Sciences with their teachers and in this way gain an understanding and orientation of what it means to read physics at the University. The visits are organized by our PR-assistant.



Sixth form pupils visiting the Department

Photo: Ari Hämäläinen



Research

HIGHLIGHTS OF RESEARCH

New relativity concept for noncommutative space-time: twisted Poincaré symmetry

Quantum field theories on noncommutative space-time have recently been intensively investigated, especially after it was shown that they can be obtained as low-energy limits of open string theory. It is well known that such a quantum field theory violates the Lorentz invariance. This fact has been a standing challenge, since most of the treatments have been done in a formally Lorentz covariant approach.

A breakthrough in the field was achieved through the newly found symmetry of noncommutative space-time under the twisted Poincaré transformations. This symmetry gives justification to all the considerations and calculations previously pre-

sented in the literature, on the basis that the twisted Poincaré symmetry has representations identical to the representations of the usual Poincaré group, classifying the particles according to their mass and spin. Thus a new concept of relativity for noncommutative space-time has arisen: while in the commutative case, relativistic invariance means symmetry of a theory under Poincaré transformations, in the noncommutative case relativistic invariance means symmetry under twisted Poincaré transformations.

M. Chaichian, P. Kulish, K. Nishijima and A. Tureanu, On a Lorentz-invariant interpretation of noncommutative space-time and its implications on quantum field theory, Phys Lett B 604 (2004) 98-102

Strengthening nanotube paper

The outstanding mechanical characteristics of individual single-walled carbon nanotubes suggest that the

tubes can be employed to make a new generation of materials with unique mechanical and electromechanical properties. Unfortunately, the stiffness of as-produced samples is quite low, since the raw powder-like material is a light but fragile network of entangled tubes and amorphous carbon. Thus, the challenge is to make macroscopic nanotube materials, which would preserve as much as possible of the stiffness and strength of individual nanotubes.

Nanotube mats, known also as nanotube buckypaper, can be produced by purifying and drying single-walled nanotube suspensions, and are now available in macroscopic centimetre-sized samples. Such mats can basically be viewed as a random quasi-two-dimensional network of nanotube bundles in which the tubes are hexagonally packed due to van der Waals interactions. However, due to a low density and weak interactions between the bundles, the experimentally measured tensile modulus, strength and strain to failure of the mats have proven to be several orders of magnitude worse than those for individual nanotubes.

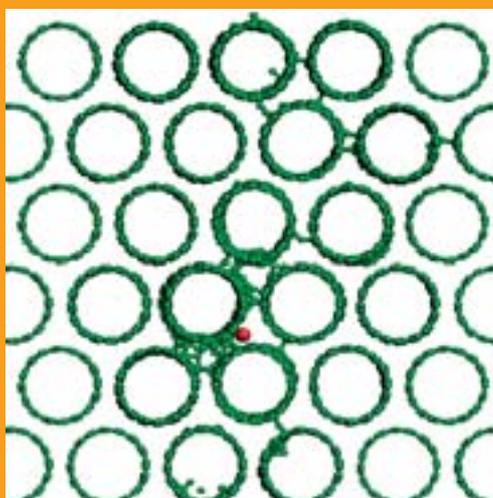
To examine the nanotube paper strength and ways to improve it we used a combination of atomistic simulations and continuum mechanics. We first determined the strength of links between two nanotubes, either for pristine nanotubes or tubes between which covalent bonds had been formed by ion irradiation. We then used this information on the link strength and density as input to an effective

medium theory model of the elastic properties of the entire nanotube mat. We showed that the stiffness and tensile strength of nanotube mats and fibers can be improved by 1–2 orders of magnitude by irradiation with energetic particles due to irradiation-induced inter-tube covalent bonds at the bundle contact areas [1]. This shows that irradiation with energetic particles is a promising tool for making macroscopic nanotube materials with excellent mechanical characteristics.

1. J. A. Åström, A. V. Krashennikov and K. Nordlund, Carbon nanotube mats and fibers with irradiation-improved mechanical characteristics: A theoretical model, Phys Rev Lett 93 (2004) 215503

Gas-Liquid Condensation of Water

Two parameters that influence the interaction of vapor molecules with liquid surfaces are the mass accommodation coefficient (the probability that a vapor molecule enters into the bulk liquid) and the thermal accommodation coefficient (the fraction of molecular collisions that result in equilibration of the energy of the impinging gas molecule with the liquid surface). We have shown, for the first time, that these coefficients are equal to 1. The determination is based on comparisons of experimental (by an expansion cloud chamber) and theoretical droplet growth curves. The result is important and provide



new insight to atmospheric cloud microphysics and consequently to the radiative balance.

1. P.W. Winkler, A. Vrtala, P.E. Wagner, M. Kulmala, K.E.J. Lehtinen and T. Vesala, *Mass and thermal accommodation during gas-liquid condensation of water*, *Phys Rev Lett* 93 (2004) 075701

2. T. Vesala, M. Kulmala, R. Rudolf, A. Vrtala and P.E. Wagner, *Models for condensational growth and evaporation of binary aerosol particles*, *J Aerosol Sci* 28 (1997) 565-598

Atmospheric Sulphuric Acid Bound to Ammonium Bisulphate Clusters

Sulphuric acid is a key vapour in the formation and growth of atmospheric particles. So far the scientific community has believed that sulphuric acid molecules are bound to clusters with a couple of water molecules, and these so-called hydrates are the basic building blocks of larger clusters. Now we have shown that it is more likely that sulphuric acid is bound to very stable ammonium bisulphate clusters, and hydrates play hardly any role. Formation of ammonium bisulphate clusters instead of hydrates reduces the predicted nucleation rates in sulphuric acid-ammonia water mixture dramatically and thus our discovery brings the theoretical results closer to observations. Also condensation efficiency of sulphuric acid is affected by the binding state of the molecule.

H. Vehkamäki, I. Napari, M. Kulmala and M. Noppel, *Stable ammonium bisulphate clusters in the atmosphere*, *Phys Rev Lett* 93 (2004) 148501

The percent of sulphuric acid (A) molecules bound to different clusters containing various amounts of ammonia (B) and water (W) molecules. The results are shown for two different ammonia mixing ratios indicated in the legend. Note that the y-axis is logarithmic.

LABORATORY OVERVIEWS

General Division

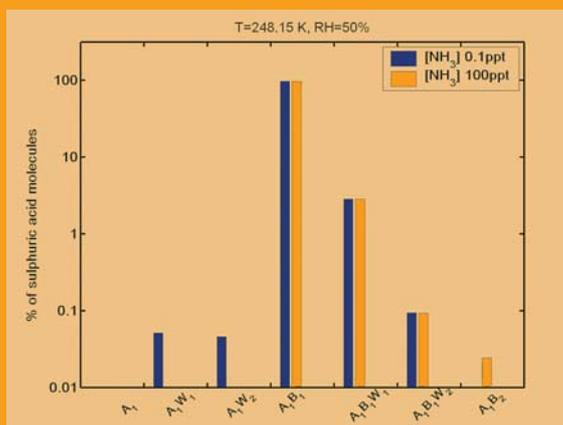
The General Division consists of several units.

Teacher Training Unit

<http://didactical.physics.helsinki.fi/>

Heimo Saarikko

The Teacher-Training unit takes the responsibility of the education of physics teachers in the Department. The main task is the education of teachers for lower and upper secondary schools, but the education is designed to give basis for physics teaching professionals in general. During recent years the unit has also expanded its impact on research of physics teaching and learning at the university level. In particular, teacher education provided by the unit has been developed further on a research basis, with strong emphasis on the conceptual structure of physics, its methodology and the role of experiments. The unit has also developed innovative environments of learning and practical solutions for teaching, which seem to be advantageous in teacher education. In this, close collaboration with the Department of Applied Sciences of Education has been very fruitful. The research based knowledge and educational solutions utilizing this knowledge support development of coherent subject knowledge and understanding of central pedagogical, discipline dependent issues of physics teaching.



The research done within the Teacher-Training Unit - research in didactical physics - is conducted in areas, where thorough understanding of the physics content and important issues related to conceptualization and learning intersect. The research we are conducting, takes the conceptual and methodological aspects of physics as its starting point and concentrates on the questions of understanding the nature of physics knowledge and its methodologies. Here the epistemological role of experiments in knowledge justification is central. Firstly, two main approaches, the generative (building meanings of concepts) and the consequential (testing the validity of concepts) have been developed further and their effectiveness has been assessed. Another research topic of interest has been focused on the role of models and modeling in formation of physics knowledge. Connected to these topics, the practical outcome has been the development of learning tools (graphical organizers, concept maps, reflective writing) supporting a metacognitive view on the subject content. Secondly, the research has been guided towards the further development of the teacher laboratories. This research has helped the unit to develop teacher laboratories to an outstanding example of research-based education of physics teachers, with a coherent and didactically well-planned curriculum as well as purposeful collection of instruments and apparatus. Within this research, there is an ongoing project intended to help teachers to manage the complexities of computer-based measurement systems and instrumentation. Another project aims to develop teaching astronomy in

secondary schools, relying much on the instruments constructed by the pupils themselves. Thirdly, the research carried out in didactical physics is traditionally focussed on teacher education, but has now been extended to cover also the problems in other branches of physics teaching in the Department. One ongoing project is to improve the effects of assessment on the quality of teaching and its possibilities in developing the teaching in the Department. Finally, research in knowledge creation and technology transfer in science organizations is conducted together with researchers based at CERN.

Development of teaching is thus strongly based on research, and a substantial part of the personnel engaged is research topics related to university level physics education. The focus has been on conceptual and processual structures of physics emphasizing the students' role in knowledge construction and learning. The continuing theme is to support the development of content knowledge of teachers in their profession and integrate subject knowledge with didactical and pedagogical views. Through several presentations in international forums, these attempts are now gaining international acknowledgement and have led to regular influx of visitors from Europe and North America to familiarize themselves with our teaching solutions. It appears that the solution we are developing for the integrated program for physics teacher education is innovative and an outstanding example of research based teaching in the European academic perspective.

Other developments include exploring the use of modern education technology, e.g. utilizing the



Photo: Seppo Andersson

Internet for web-based instruction and microcomputer-based laboratory systems. More web-based material has been made available. The unit also supports the electronic library, containing theses and other material helping to disseminate the results of research and their applicability in school teaching. Supplementary training courses for in-service elementary school class teachers are continued in co-operation with the Department of Chemistry and the Department of Applied Sciences of Education, and new courses have been designed as well. Among other things, this includes developing further the courses for in-service training for both primary and secondary school teachers.

The public outreach and the contacts with the schools are an important part of the activities of the teacher-training unit. Consequently, the Teacher Training Unit has been a driving force in the creation and operation of the LUMA centre at the Kumpula campus (<http://www.helsinki.fi/LUMA>). LUMA is a centre promoting the teaching of biology, physics, chemistry, geography, mathematics and computer science and enhancing interaction between schools, universities and business and industry. LUMA serves as a centre for education, research, development and co-operation. Through the centre, the teacher-training unit has increased the public outreach of its research results and practical solutions on physics teaching.

Electronics Research Unit

<http://electronics.physics.helsinki.fi/>

Heimo Saarikko

The development of novel measurement methods and sensors combining ultrasonics, optics, electronics and advanced signal processing continued.

Paper, wood and rock characterization

The characterization of paper and paper coatings continued. Wetting properties of several paper grades were studied by recording the light reflected from a paper surface. The results showed that our apparatus was capable of following a liquid front that was penetrating mainly into the thickness direction of the paper. The project, in which the formation of a paper coating layer and corresponding changes in its mechanical parameters during drying was studied, continued. Ultrasonic shear wave techniques relying on measuring the amplitude and

phase changes of a wave reflected from a reference material-sample interface make it possible to measure the elastic properties of the coating layer during formation and drying.

The experiments with an ultrasonic method to determine the impact of heat treatment on the elastic modulus and the acoustic nonlinearity parameter of thermally treated wood continued. Initial tests to estimate the acoustoelastic parameters in thermowood were conducted. The aim of this research is to develop a method for classification and quality assurance of thermowood products. Parallel to these efforts the ultrasonic characterization of unmodified wood was continued in co-operation with the Division of X-ray Physics. The modulus of elasticity, the acoustic nonlinearity parameter, and the acoustoelastic parameter as a function of the year ring in longitudinal, tangential and radial direction was determined from time of flight measurements by longitudinal and shearwaves.

In a project with the Division of Geophysics ultrasonic characterization of mechanical and structural properties of special kinds of rock samples was carried out. During this year the first measurements using a novel method for ultrasonic quantification of meteorite and rock porosity were performed. As a milestone on our way to prove the suitability of this method to determine the structural properties of rock materials the first results measured on microsphere - silicon samples of 5-50% porosity were obtained.

Instrumentation

Our scanning white light interferometer was applied in scientific and industrial venues. The capabilities of this instrument were improved and a way to measure both the thickness and group refractive index by one rapid measurement was conceived. These measurements were started with capacitor film samples provided by Evox Rifa. Extensive research was carried out in collaboration with the Helsinki Institute of Physics in the "A Large Ion Collider Experiment" ALICE at CERN, collaboration for finding nondestructive quality control of TAB (tape automated bonding) interconnections.

Collaboration with the group of Dr. Roman Tuma from the Institute of Biotechnology was begun. An Optical Tweezers instrument was built at the Electronics Research Unit. The instrument is capable of measuring both pico-Newton forces acting on an optically trapped microsphere as well as the position

of the sphere with nanometre resolution. The resolution and stability of the instrument is still the subject of development. The instrument will be used for studying biophysical processes at single molecule level in molecular motors from bacteriophages.

In collaboration with the Prof. Khuri-Yakub group at Stanford University studies on the relative merits of new designs and modes of operation of capacitive micromachined ultrasonic transducers (CMUT) compared to classical CMUTs were carried out. Studies of charging and operational hysteresis in these silicon devices were also carried out. The CMUTs are expected to replace the current PZT transducers in medical applications.

The research to use posturography as a method for measuring sleep deprivation was continued together with the Finnish Institute of Occupational Health.

In another industrial project we developed and built a power cycling system for lifetime acceleration studies of electronic components in cooperation with Nokia Ltd. The system is fast and able to produce realistic failures in the devices under test (DUT). The fully automated system is designed around a multitude of customized Peltier modules cycling the DUTs between $-20\text{ }^{\circ}\text{C}$ to $100\text{ }^{\circ}\text{C}$ in controlled environmental conditions.

Last, but not least: in the third quarter of this year Vaisala Oyj launched a new multi-sensor weather station whose liquid precipitation sensor prototype was invented and developed in our laboratory during the years 1998–2000.

Medical Physics Group

Sauli Savolainen

Dosimetric studies were performed at the FIR 1 research reactor to enable boron neutron capture (BNCT) treatments with a wider choice of beam apertures and surface-to-aperture distances due to the new BNCT targets – recurrent head and neck tumours. Intracranial BNCT treatment in two protocols continued and a new protocol for recurrent head and neck tumours was started. In the field of medical imaging applications, the utilisation of multimodal imaging techniques has also had a powerful impact.

Gel dosimetry studies were continued by applying a new dosimeter type for the verification of dose

distributions. MAGIC-type gels can be prepared with relative ease and are suitable for various dosimetric purposes. An enhanced algorithm for blood boron estimation for BNCT treatments was developed and implemented. For improved treatment planning in BNCT it is beneficial if the *in vivo* ^{10}B -distribution in the target area could be determined. The BNCT ^{10}B -carrier currently in use in the Finnish BNCT project, BPA-fructose, allows the use of ^1H MRS for this purpose. In our recent phantom and *in vivo* studies we have evaluated the applicability of ^1H MRS to detect BPA in a residual tumour enveloping a blood filled resection cavity. Currently we are studying the possibilities to use ^1H spectroscopic imaging in the ^{10}B -distribution determination.

In the field of medical image processing, image fusion and segmentation were the target areas. Methods were developed for fusion of MR (magnetic resonance) and SPECT (single photon emission computed tomography) images and MEG (magneto encephalography) data, the main application being the diagnosis and treatment of epilepsy. Combined MR imaging, transcranial magnetic stimulation (TMS) and EEG (electro encephalogram) techniques have been applied to study the neuronal connectivity of the healthy human brain. The collaboration with the BioMag Laboratory was continued by quantifying the physiology of the healthy brain using simultaneous TMS and EEG registrations. In the head and neck BNCT, image fusion was used to co-registrate PET (positron emission tomography), CT (computerized tomography) and MR images for treatment planning. Pre- and post-treatment MR images were fused to study the pattern of glioblastoma recurrence in patients treated with BNCT. In addition, segmentation of microscopic neurone nuclei images was studied for microdosimetric modelling in BNCT.

All the research has been done in collaboration with different departments of the Helsinki University Hospital. The medical physics research group is also functioning within the Functional Brain Research Unit, Helsinki Brain Research Center which has been granted a status of excellence by the Academy of Finland for the years 2002–2007.

The Academy of Finland and the State Subsidy for University Hospitals, which are gratefully acknowledged, have financed the Laboratory of Medical Physics.

Space Research Unit

<http://theory.physics.helsinki.fi/~space/>

Hannu Koskinen

The Kumpula Campus is becoming the strongest space research environment in Finland. The Faculty of Science has identified space research as one of the top priorities in its strategy and the Finnish Meteorological Institute (FMI) will bring its space research activities to the Campus in 2005. Consequently, a strategy planning work was initiated in 2004 with the goal of establishing a joint Kumpula Space Centre at the Campus. The activities of the Space Centre will be based on research projects at the University and FMI and it will also provide technological and computing support for space instrument development and operations as well as data reception and processing.

The high priority of space research at the Faculty level was also acknowledged by the Rector of the University, which led to establishment of a new lecturer position in space physics in 2004. This gives important long-term stability to the research at the Department of Physical Sciences in a field that is critically dependent on external funding sources.

Presently the active areas in space research of the Department of Physical Sciences include solar system plasma physics, cosmology, planetary meteorology, instrumentation for high-energy astrophysical observations, and geophysical studies of past meteorite impacts. These fields have evolved rather independently within different research groups as a result of their particular expertise and collaboration with scientists in other parts of the University and elsewhere. Consequently, space research is conducted in the Divisions of Atmospheric Sciences, Geophysics, High-Energy Physics, Theoretical Physics, and X-ray Physics, and in the Detector Laboratory. The task of the Space Research Unit is to coordinate the space efforts within these Divisions and it is responsible for the external relationships and reporting of the research activities.

The personnel resources and teaching are distributed among the various Divisions according to their respective expertise and responsibilities. The total amount of person years in space research at the Department of Physical Sciences in 2004 was 23 and the total expenditure about 1.1 million euros. About 64 % of the total expenditure came from external sources. For the last several years the nation-

al Antares Programme funded by the Academy of Finland and the National Technology Agency, Tekes (2001- 2004) has been a major element in the Department's space research. The Department had a leading role in three Antares consortia: the scientific activities of the consortium participating in the European Space Agency's (ESA) Planck satellite mission are co-ordinated by Prof. Kari Enqvist, the space weather research consortium by Prof. Hannu Koskinen and the consortium to study small-scale weather phenomena on Mars by Prof. Hannu Savijärvi. Furthermore, the Division of X-ray Physics and the Detector Laboratory had significant participation in the high-energy astrophysics consortium.

Space research is always conducted in wide national and international co-operation. In space physics the collaboration with the FMI is based on the jointly funded professorship. In cosmology and high-energy detection techniques the most important collaborative partner is the Helsinki Institute of Physics (HIP). The collaboration within the Antares programme involved all space physics and astrophysics laboratories in Finland and several industrial partners. The ties to the European Centre of Nuclear Research (CERN) are close: for example similar detection technologies are developed for space and elementary particle research. The major research efforts are closely related to ESA and NASA science missions and there are also linkages between ESA and CERN, in particular in the field of fundamental physics.

The senior scientists at the Department had several visible positions in national and international space organizations in 2004. Prof. Hannu Koskinen is a member of the Finnish Delegation of the ESA Science Programme Committee, the chairman of the Finnish National Committee of COSPAR, representative of Finland in the COSPAR Council and a member of the Management and Operations Working Group of the Living With a Star program of NASA. In 2004 he became a corresponding member of the International Academy of Astronautics. Prof. Kari Enqvist became in 2004 a member of the European Space Science Committee (ESSC) of the European Science Foundation (ESF). Prof. Lauri Pesonen continued to represent Finland in the European Science Foundation's Impact programme and Prof. Hannu Savijärvi is a member of the International Commission of Planetary Atmospheres and their Evolution. Dr. Rami Vainio is a co-chair of one of the working groups in the EU/ESF COST action on space weather.

Deformation of the nucleon and the $\Delta(1232)$ wave functions was studied with phenomenological quark model wave functions that were constructed to describe the electromagnetic form factors of the proton in the impulse approximation with three different subgroups of the Poincaré group as the kinematic subgroup. It was shown that in all cases a small admixture of a mixed symmetry S -state wave function is sufficient for a description of the experimental electric form factor of the neutron.

It was found that in contrast the nucleon elastic form factors displayed very little sensitivity to spatially "deformed" D -state admixtures. The calculated $E2/M1$ ratio in electromagnetic decay of the $\Delta(1232)$ proved to be sensitive to D -state admixtures in both the nucleon and the $\Delta(1232)$ wave functions. In contrast to this the calculated $C2/M1$ ratio was found to be insensitive to such D -state admixtures. The empirically found structure in the $E2/M1$ ratio at low momentum transfer could not be described by D -state admixtures alone, and may most likely be ascribed to sea-quark or "meson cloud" configurations.

The magnetic moments of the strange and charm hyperons were calculated in instant, point and front form kinematics in the impulse approximation with phenomenological quark model wave functions. The sensitivity to the constituent mass was shown to be small in all cases, a result that is very different to that in the nonrelativistic quark model. Overall the impulse approximation appears to provide the best phenomenological description of the experimental magnetic moments in instant and front form kinematics.

The axial transition form factors and the pion decay widths of the low lying nucleon and $\Delta(1232)$ resonances were calculated in the covariant quark model in instant, point and front form kinematics. The calculated pion decay widths were systematically smaller than the experimental decay widths both in the case of the $\Delta(1232)$ and the other low lying positive parity resonances. This suggests that these resonances contain significant sea-quark configurations, which are not contained in the constituent valence quark model.

Substantial construction of new facilities and equipment to be used for materials research has governed laboratory activity during the year 2004. The launching of new research themes, pertinent to these facilities, will further strengthen the complementary nature of our experimental and computational studies.

The construction of equipment in the Nano hall, which started in 2003, was continued in 2004 as follows: (i) the installation of an ultra-high-vacuum sample transport line for FaNaDe (facility for nanostructure depositions) was completed, (ii) the construction of LEIDA (low energy ion deposition accelerator) was continued, and (iii) four ultra-high-vacuum sample chambers for FaNaDe were installed. A cluster beam deposition system will soon be ready for commissioning with a research programme covering two main lines, namely, nanocluster deposition of metals on single-crystalline metallic substrates and nanocluster deposition of Si-Ge semiconductor alloys of various chemical compositions on Si. The depositions are performed either at very low fluences, resulting in individual nanoclusters that relax on the substrate and eventually may coalesce, or at relatively high fluences in order to form a complete monolayer and possibly thicker thin films. From the point of view of advanced characterization, the focus has been set on atomic force microscopy (AFM) of noble-metal thin films as well as of organic thin films (which are the basic elements for chemical sensors).

A noteworthy research effort was initiated in collaboration with the positron spectroscopy group at the Helsinki University of Technology. A facility was constructed that provides vacancy production by energetic protons and their detection by positron annihilation spectroscopy at low temperatures. An important goal of the research is to improve the understanding of the mechanisms generating ion bombardment induced point defects and to study their behaviour during annealing for selected novel materials. It is expected that the results will also provide pertinent information needed in diffusion mechanism related research.

Studies on first wall materials considered for use in the new international thermonuclear reactor ITER were continued as a part of an EU project. Studies on flaking of carbon films were complemented with the deposition hydrogen doped carbon films on

tungsten and molybdenum substrates. Tungsten is considered as a plasma facing material in places with low plasma loads. Hydrogen-metal interactions were studied in the framework of hydrogen diffusion and trapping, and also as an investigation into different processes between hydrogen and metal surfaces. We have now included the surface area concentration and activation barriers between the surface and the bulk in a numerical method, which describes the hydrogen desorption from metal surfaces more realistically than models used in the literature. Experiments on the desorption of deuterium molecules from tungsten surfaces were compared with the numerical model, giving important information on surface and surface-interface activation energies.

Ferroelectric properties of strontium tantalate thin films produced by the atomic layer deposition (ALD) method have been investigated in a co-operation with the Laboratory of Inorganic Chemistry of the University of Helsinki. These materials are promising capacitor dielectrics for ferromagnetic non-volatile random access memories. The time-of-flight elastic recoil detection analysis (TOF-ERDA) method in the framework of high-energy heavy ion beams was utilized.

Heavy-ion high-energy irradiations were used to obtain desired defect depth profiles in semiconductor saturable absorber mirrors as a part of the national QUEST consortium, concerned with the

fundamental research of quantum-regime optical wavelength-scale semiconductors in an effort to improve the understanding of the physics of ultra-fast optical phenomena in matter and demonstrate such phenomena in actual devices. For the speed of the semiconductor devices based on saturable absorption and limited by the lifetime of the photo-excited carriers, sub-picosecond lifetimes were achieved in studies of room-temperature carrier decay and rise rates as functions of 10-MeV Ni⁺ ion implantations in technologically important InGaAs / GaAs quantum wells.

The experimental activities of the laboratory have been complemented by computer simulations of nanostructures, compound semiconductors and fusion reactor materials. A multiscale modelling scheme enabled us to determine the mechanisms and time scale at which Cu nanoclusters become epitaxial and flatten out on Cu surfaces. This enables the selection of suitable fluxes and deposition temperatures for the upcoming experimental activities in cluster deposition. The studies of carbon nanotubes, performed in the framework of the national ELENA collaboration consortium, showed that ion irradiation can be used to strengthen multiwalled nanotubes and buckypaper manufactured from single-walled tubes. Defect cluster sizes in the compound semiconductor GaAsN were also studied, as part of the national QUEST consortium. To enable



Photo: Eero Roine

simulation of plasma-wall interactions in the ITER fusion reactor divertors, we developed a reactive interatomic potential for the W-C-H ternary system, and used this to explain the dramatic difference between He and H-induced blistering of W and erosion mechanisms of tungsten carbide. A kick-start on coupling molecular dynamics (MD) computer simulations with transmission electron microscopy (TEM) image simulations of nanocluster deposition has shown an enormous potential in as far as experimental comparisons are concerned, and more specifically, on the microstructure (orientation, defects, disorder) of simulated clusters interpreted in the frame of a microscopist's point of view. A series of case studies of Ge nanocluster deposition onto Si substrates have been carried out and will be benchmarked against the very few transmission electron microscopy observations reported in the literature.

The merging of the Monte Carlo calculations, using ion packets and plural and multiple scattering, and nuclear models in the modelling of ion scattering phenomena is in progress. These computations are important in the correct interpretation of ion scattering spectra especially in the presence of resonances.

We are participating in a project for the inter-comparison of software for ion beam data analysis in collaboration within the IAEA. A worldwide effort, coordinated by the authors of 12 software programs, is being undertaken, in order to establish the current status, key problems and essential growth points of the data analysis techniques. We have participated in a round robin project to compare the results of measurements on H implantation distributions in Si by elastic recoil detection. The participants were seven laboratories from Europe, Australia, Canada and the USA. A total combined uncertainty of 6% of all the results was observed.

Diffusion studies employing the modified radiotracer technique have been continued with implantations carried out at the facilities of ISOLDE/CERN, Universities of Bonn and Jyväskylä. The systematic study on the fluence-dependence of ion implanted As diffusion in relaxed $\text{Si}_{1-x}\text{Ge}_x$ alloys and silicon was completed.

The studies of irradiated polymer films for fuel cell applications have been continued. The radioactivities produced in these films have been examined further. The suitability of two synthetic polymers (PE and PS) and four fluoropolymers (PVF, PVDF, PFA and FEP) for proton beam dosimetry has been investigat-

ed. This research is done in co-operation with the Laboratory of Polymer Chemistry and the Laboratory of Radiochemistry of the University of Helsinki.

The long-term research project related to amorphous diamond coatings has now been completed in the research programme of the laboratory.

The laser physics group continued to study non-linear dynamics in lasers subjected to external optical injection. The lasers of interest are edge-emitting semiconductor lasers, VCSELs and diode-pumped micro-cavity lasers. The interpretation of dynamics is explored experimentally utilizing optical spectra, intensity noise spectra and through time-series measurements. In addition, we have performed computer simulations of our experiments. The collaboration with the Finnish Geodetic Institute has concerned the optics of frequency stabilised gravimeter lasers.

The ion beam equipment (TAMIA (tandem accelerator for mega-electron volt ion beam analysis) and KIIA (kilo-electron volt ion implantation accelerator)) was successfully in operation during the year 2004. Ion beams of a wide range of elements (from H to Au) at energies from 30 to 520 keV were implanted, using KIIA, into various solid materials. Most of the beam time was devoted to implantation, with some experiments on defect formation by ion irradiation. The percentage fraction of beam time of TAMIA was distributed among different elements as follows: hydrogen (15), helium (22), lithium-7 (7), nitrogen-15 (4), nickel-58 (6), bromium-79 (12), and iodine-127 (18). The remaining 16% of the beam time was devoted to accelerator mass spectrometry of C-14. An unscheduled service period of TAMIA was required for the replacement of the charging belt. A new type of belt (a conveyor belt manufactured by Siegling) was installed. The charging screens were replaced with a set of charging needles, both at the ground potential and at the high-voltage terminal. The needles enable a non-contact charging. A new beam energy stabilization system purchased from the company NEC was also installed and is being tested. A 1600-L/s turbopump was installed at the TAMIA injector, replacing a 600-L/s ion pump and enabling an order of magnitude better vacuum in the low-energy accelerating tubes.

The laboratory arranged the COSIRES 2004 conference on June 28 - July 2, 2004. This was the seventh conference in the series of international conferences on computer simulation of radiation effects in solids, held biennially since 1992. We hosted 104

persons in Helsinki, who presented 12 invited talks, 29 oral presentations as well as about 50 posters. The presentations regarded computer modelling of timely topics in ion beam physics, ranging from method development to studies of nanostructures, semiconductors and fusion reactor materials. The proceedings of the conference will have 64 papers and be published in the regularly appearing journal Nuclear Instruments and Methods in Physics Research B. The strength of the conference series was reflected in that about half of the attendees were graduate students or young post docs.

The Socrates/Erasmus Intensive Programme “Ion Beam, Photon and Nuclear Methods in Studies of Nanostructured Materials” was approved by the European Commission and shall be co-ordinated by the laboratory. The Intensive Programme has eleven participating institutions from ten countries.

High Energy Physics Division

www.physics.helsinki.fi/~www_sefo/

Theoretical High Energy Physics

Masud Chaichian

The Theoretical Group of the High Energy Physics Division has a broad area of research interests, covering Quantum Field Theory, Noncommutative Geometry, Gauge and String Theory, Higher Dimensional Theories, Quantum Chromodynamics QCD and Particle Phenomenology.

The group has continued its studies of quantum field theory on noncommutative (NC) space-time, approaching its space-time symmetries. In this direction the group has made a breakthrough by showing that, although NC QFT violates the Lorentz invariance in the usual sense, they have a twisted Poincaré symmetry, whose generators are the same as the usual Poincaré generators. Therefore, the particles in NC space-time are classified, just like in the commutative space-time, according to their mass and spin. This new symmetry gives justification to all the previous treatments and calculations, such as perturbative unitarity, UV/IR mixing, NC instantons and relation to matrix models, made in the literature in a formally Lorentz invariant form in spite of its violation. Such a symmetry, in addition, leads to a new concept of relativistic invariance defined for the noncommutative space-time, which has been explored in the formulation and proof of an analog of

Haag’s theorem in QFT. The group has further obtained all the exact results of QFT, i.e. the dispersion relations, CPT and spin-statistics theorems and the Froissart bound on the high energy growth of the total cross section, also in the case of NC space-time, using the developed axiomatic formulation of such theories. The group has also continued the study of model building in the noncommutative context, proposing a gauge-invariant and anomaly-free noncommutative version of the Standard Model.

In hadron physics one focus has been on the dynamics of hard diffractive scattering. We have shown that the diffractive events seen in Deep Inelastic Scattering arise as a consequence of the rescattering of the struck quark on its way out of the target. This shows that the ‘Pomeron’ is not a part of the target wave function but a consequence of multiple scattering. The relative suppression of diffraction in hadron induced processes as compared to lepton scattering can be understood as a consequence of rescattering involving the projectile hadron spectator system.

Another focus has been on questions related to QCD at long distances, where the non-trivial vacuum structure is important. We have studied the effects of a constant color field on quark and gluon propagation, and on the quark correction to the photon self-energy. Propagators that are “dressed” by the color field have no on-shell poles and are thus removed from the set of asymptotic states. The dressing also removes the infrared divergences of quark loops. This approach should allow addressing questions related to analyticity and unitarity in situations where the fundamental fields do not appear as asymptotic states.

In beyond the Standard Model -phenomenology the focus has been in supersymmetric models and higher dimensional models. We have studied the Higgs detection in the case of the large extra dimensions. We found that in most part of the parameter space the detection of Higgs looks promising. In the models with small extra dimensions we have investigated disentangling a Higgs boson from a radion. We found it useful to study the gluon decay channel of the scalars in a linear collider.

In supersymmetric models, we have investigated the single production of sneutrinos, when R-parity is broken. Single production enlarges the kinematic range of a collider. We found that while the sneutrinos can be detected in a four b-jet decay channel at LHC, separation between a Higgs boson

and a sneutrino requires detailed knowledge of the branching ratios. We have also analyzed the gluino and chargino contributions to the CP asymmetries in $B \rightarrow \Phi K(S)$ and $B \rightarrow \eta' K(S)$. We adopted a model independent approach based on mass insertion approximation, and used both QCD and naive factorization approach to calculate the hadronic matrix element. Correlations between the decays were investigated.

The Theoretical High Energy Physics Group maintains close research and scientific contacts with the Helsinki Institute of Physics (HIP), several theoretical high energy groups in Europe and in other Nordic countries, as well as with CERN and various research centers in USA and Japan.

Experimental High Energy Physics

Risto Orava

Research of the experimental high energy physics group of the Department of Physical Sciences and HIP (Helsinki Institute of Physics) aims at physics contributions to energy frontier experiments at CERN and Fermilab. The group has placed its long-term emphasis on QCD, especially in the heavy quark sector. To be able to have an impact in a leading experiment, the group has systematically invested in development of experimental instrumentation and software tools for b- and t-quark analysis. This de-

velopment work represents a long-term investment on precision detectors and software intended for jet reconstruction and heavy quark tagging.

In 2004, the DELPHI collaboration focussed on finalizing the analyses of the data collected during 1989-2000 at the Large Electron Positron collider at CERN.

The highlights of the Helsinki group activities consist of the search for charged Higgs bosons and establishing a model independent lower limit on the charged Higgs mass of 74.4 GeV, the indication of presence of Bose-Einstein correlations between particles emitted from different W's in $e^+e^- \rightarrow W^+W^-$, the observation of depletion of fragmentation particles at small angles in b-jets, the so-called dead cone effect and the inclusive measurement of the lepton momentum spectra in semileptonic B decays, improving the accuracy of the determination of the quark mixing matrix element $|V_{cb}|$. The group has traditionally had a prominent role in b-quark tagging in the DELPHI experiment and in construction and operational aspects of the Micro Vertex detector.

On the basis of its reputation built in the LEP-DELPHI experiment, the Helsinki group was recently accepted to join the CDF experiment at the Fermilab Tevatron antiproton-proton collider. Tevatron is currently the energy frontier instrument in high energy physics and represents currently the only active experiment in Finland in this field. At present, Tevatron is the only collider facility with which the heaviest matter particles, the top quarks, can be



"Strong and Electroweak Matter 2004"
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Photo: Stefan Michalski

produced. The collider fills up the gap between the recently finished LEP program and the forthcoming new LHC collider now under construction at CERN and provides an indispensable training ground for the experimentalists aiming at physics contributions at the LHC. The Helsinki group plans to analyse the properties of the top quark in detail and, in particular, to develop novel ways of precisely measuring the top quark mass. Combined together with the W-mass measurement, the more precise top mass pins down the allowed region of the Standard Model Higgs boson.

The expertise acquired in the construction and operation of DELPHI's vertex detector is now exploited in the involvement in both online and offline operations of the CDF silicon vertex detector.

The Helsinki group participates in physics planning, design and construction of the TOTEM experiment at the LHC collider. The project offers a direct continuation for the group's earlier LEP and ongoing Tevatron based QCD analysis and, from the year 2007 on, provides unprecedented access to precision studies of gluons - the carriers of strong force. Already during the preparatory stages of the experiment, the group has gained the coordinating role in TOTEM physics analysis (physics coordination and chairmanship of the physics advisory board) and has been given major responsibilities in construction of some of the key parts of the experiment (T2 tracking station and microstations).

In 2004 the group has continued the simulation studies of the central diffractive process: $pp \rightarrow p + H + p$ and has gained a central role as an expert group concerning diffractive physics at the LHC. As a benchmark, limits of observation of the standard model Higgs boson at the LHC have been established. The group is responsible for the Gas Electron Multiplier (GEM) detector based T2 tracking station of TOTEM. During the autumn in 2004 the first GEM detectors, specifically designed for TOTEM, were tested in a CERN test beam.

The group has made important new innovations in the field of 3D silicon detector structures in cooperation with the Technical Research Centre of Finland (VTT). Novel detector performance has been simulated in 3D for the first time and test structures have been processed at VTT and tested at the Detector Laboratory in Kumpula. These detectors are intended for the leading proton measurement within the microstations under development in Finland.

Theoretical Physics Division

www.physics.helsinki.fi/~tfo_www/

Particle Physics

Keijo Kajantie

Research in the division is mainly carried out in particle and space physics. In particle physics the topics of study are particle cosmology, theory of hot and dense quark-gluon plasma, mathematical physics and the physics of hadrons. Research in space physics will be reported on in connection with the departmental Space Research Unit.

In particle cosmology, studies of the nature of the primordial density fluctuations of the universe have been continued. We consider the possibility of correlated adiabatic and isocurvature fluctuations with different spectral indices. We are now using also the data on the large-scale galaxy distribution (Sloan Digital Sky Survey) in addition to cosmic microwave background anisotropy (WMAP satellite), to constrain these fluctuations.

To constrain hybrid-type inflation theories, non-gaussianities of the cosmic microwave background have been studied. Possible holographic connections between the equation of state of dark energy and the cosmic microwave background at large angles have also been investigated both theoretically and by analysing the cosmological data.

Perhaps the most central issue in cosmology is the observationally confirmed acceleration of the expansion of the universe. This can be explained either in terms of a new energy component in the universe, called "dark energy", or by a modification of the laws of gravity (i.e., general relativity) at large distance scales. We have studied how various candidates for dark energy or modified gravity affect the microwave background radiation. We have so far obtained results for one such model, the so-called "Cardassian" model. We have interpreted it either as a dark energy component, or a modification to general relativity. In both cases we found that the effect of fluctuations in the Cardassian sector on large-scale microwave anisotropy ruins the agreement with observations.

We continued to participate in the European Planck satellite project as a part of the CTP working group, which is trying to establish ways to estimate the temperature and polarization spectra of the microwave background radiation. The activity has so far centered on algorithms and codes for making

full-sky maps of the microwave background. We have extended our “destriping” map-making method to polarization maps in addition to temperature maps. Our temperature map-making code has been now included in the “Demonstration Model” software pipeline of the Planck LFI Data Processing Centre; and we will soon submit also the polarization map-making code.

The free energy of hot quark-gluon plasma is remarkable in that its perturbative expansion, which due to asymptotic freedom could be expected to be very accurate at very high temperature, actually at sixth order contains a non-perturbative term. As any particle masses, it can only be computed numerically. It has been a long-standing problem how this computation should be organized. We have finally solved this by formulating a precise set-up therefore, by performing several required intermediate analytic and numerical steps and by defining precisely what still has to be done: one extremely demanding but feasible analytic computation and one numerical computation. Both are under way.

In the phenomenology of quark-gluon plasma we have earlier devoted much effort to the computation of gluon production in the classical field model of heavy ion collisions. This will now be extended to a computation of quark-antiquark production. This involves a significant increase in complexity since it necessitates a numerical integration of the Dirac equation in a completely general only numerically known color field. This has been explicitly done in time + one space dimension to set the stage for a full 1+3 dimensional case. The result will have important phenomenological applications for thermalisation.

In hadron physics the study of heavy-light quark systems using lattice methods has been continued by extending the earlier work in two ways. Firstly, the lattice calculations are now performed with dynamical fermions compared with the earlier quenched approximation. Secondly, emphasis is on a single heavy-light meson – a system that can be compared with recent B_s data.

On a more phenomenological level, charge symmetry breaking has been studied in mesonic inelasticities in few-nucleon systems, e.g. in a theoretical interpretation of the first observation of the isospin forbidden reaction $d + d \rightarrow \alpha + \pi^0$. This symmetry and its breaking is closely linked with fundamental QCD dynamics, in particular with the u and d quark mass differences, effects of which are investigated with effective field theory techniques. Also,

nuclear interactions of the eta-mesons have been studied. The work on a new pion-nucleon partial wave analysis is continuing. Expansion methods are employed to build in fixed-t analyticity. The aim is to determine the pion-nucleon coupling constant and the sigma-term with high accuracy.

A novel method has been developed for constructing unconstrained canonical variables in classical Yang-Mills theory. When applied to SU(2) gauge fields, it yields a local unconstrained Hamiltonian that decomposes into a finite Laurent series in powers of the coupling constant. This work is now being generalized to theories involving fermions and higher dimensional Lie groups. Classical properties of the SU(2) Hamiltonian are also under study.

As a part of a “general” investigation of the implementation of Gauss’s law in Yang-Mills theory, a uniqueness theorem for the solutions of covariant Poisson equations, with an arbitrary semi simple gauge group, in space-dimensions $d = 1, 2,$ and 3 has been proved.

The Division works in close connection with the Helsinki Institute of Physics. Nationally, the contacts are close with the universities of Turku and Jyväskylä and with the Finnish Meteorological Institute. The supercomputing facilities of the Finnish Center for Scientific Computing (CSC-Tieteellinen laskenta Oy) are indispensable for many workers within the division. Graduate students are supported by the Graduate school in particle and nuclear physics and by the Graduate school in astronomy and space physics. Internationally, contacts are particularly close with the Brookhaven National Laboratory, CERN, DESY, Jülich research centre, Nordita, Saclay and Universities in Aachen, Bern, Bielefeld, Cambridge, Lausanne, Liverpool, Lund and Oslo. The Division is associated with two EU networks and one 6th framework programme Integrated Infrastructure Initiative.

Division of X-ray Physics

www.physics.helsinki.fi/~xray_www/

Keijo Hämäläinen

The main areas of research within the division of X-ray physics are soft and hard condensed matter physics, biophysics and applied research including activities in medical imaging, X-ray space science as well as small applied projects with industrial partners. The emphasis of the research is on the fundamental consideration of the interaction processes between ra-

diation and matter giving thorough understanding of various x-ray based characterization techniques of novel materials. Long experience and participation in construction of pioneering instrumentation give a unique asset to get insight on the electronic structure of complex materials beyond the routine characterization techniques. Apart of our home-based arsenal of x-ray sources with various diffractometers and spectrometers, synchrotron radiation experiments play an important role in our experimental activities. Our division has the most active unit in Finland carrying out experimental projects at the European Synchrotron Radiation Facility (ESRF, Grenoble, France) while we constantly utilize also various third and second generation synchrotron radiation facilities around the globe.

A total of 36 persons worked in our division during 2004 adding up to 27 person-years (including graduate and under-graduate students). The change of generation of professors was completed during the fall 2004 when Ritva Serimaa was appointed to a newly established chair of experimental soft condensed matter physics. This nomination will strongly support the still increasing activities in the study of weakly ordered materials. The same experimental techniques will also play a vital role in biophysics where Prof. Arto Annala (with a joined chair with the Department of Biosciences and the Institute of Biotechnology) is bringing expertise and broadening the research topics to the bio-related materials. Prof. Keijo Hämäläinen together with acting Prof. Seppo Manninen concentrate more on the fundamental research on hard condensed matter where recently more resources are allocated to support the computational activities which are essential to support the solely synchrotron radiation based experimental work. Prof. emeritus Pekka Suortti continues his activity in medical imaging in successful collaboration with medical researchers and the ESRF. Positive news for our space-science projects is that the X-ray solar monitor (XSM) on board the ESA SMART-1 spacecraft is still working after one year in space and ready for data acquisition when it will reach the moon in November 2004.

Soft condensed matter and biophysics research has been based on the use of x-rays, neutrons, and NMR. Studies on self-assembly of polymeric supramolecules, including both synthetic polymers and proteins have been carried out in collaboration with Helsinki University of Technology, Tampere University of Technology and VTT. Topics of x-ray and neu-

tron scattering studies have also included biosystems: structure of light harvesting chlorosomes and wood cell wall.

Research topics for biophysics include studies on conformational changes in proteins that range from subtle side chain reorientations to folding of a completely random polypeptide segment. The latter has been studied using a simple model system to see how residual dipolar couplings report from a helix-coil transition and from a loop closure. Relative orientations of chemical bonds in amino acids can be determined using residual dipolar couplings, available from NMR measurements in aqueous dilute liquid crystals.

Hard condensed matter research has been concentrated on utilization of inelastic x-ray scattering. Various sub-techniques requiring the use of synchrotron radiation have been exploited, namely, Compton scattering, X-ray Raman scattering, non-resonant scattering with few eV-energy loss as well as emission spectroscopy. Efforts have also been continued to improve the theoretical and computational support within the Department. The most interesting results include experimental evidence of electronic structure changes at the critical temperature for MgB_2 superconductor and first results on Compton scattering on water.

Medical imaging projects have been continued in close collaboration with the ESRF and the Helsinki University Central Hospital. These include lung imaging utilizing the so-called K-edge Subtraction (KES) method, breast cancer studies with the Diffraction Enhanced Imaging (DEI) as well as with small-angle x-ray scattering.

Division of Atmospheric Sciences

www.atm.helsinki.fi

Markku Kulmala

The main research activities can be divided to a) aerosol and environmental physics, b) micrometeorology and forest-atmosphere relations, c) dynamical and physical meteorology and d) space physics. Five professors and about 55 scientists (including doctoral students) worked in the division in 2004. The space physics activities are described in a separate section.

Studies on heat, mass and momentum transfer, nucleation, condensation, aerosol dynamics, aerosol measurement technique, atmospheric aerosols, deposition and fluxes of atmospheric gases, cloud microphysics, atmospheric physics, atmospheric radiation,

mesoscale and Martian meteorology, climate and Radar meteorology were performed. The main aim of the studies is to develop a practical application, based on mastering fundamental physical, chemical and meteorological phenomena to solve different atmosphere-related problems.

The Division operates together with the Department of Forest Ecology at two field stations: the SMEAR II station (Station for Measuring Forest Ecosystem-Atmosphere Relations) in Hyytiälä and the SMEAR I station in Värriö. During 2004 the new measurement station SMEAR III (urban SMEAR) has been constructed in the Kumpula Campus area. The Division has possession of a) a weather radar, b) aerosol and micrometeorological instruments for field campaigns and c) a laboratory for research of aerosol microphysics. During 2004 the development and construction of a new weather radar has been performed in collaboration with Vaisala Oyj.

The Division has great experience in numerical modelling of the atmosphere (e.g. improving radiation schemes for General Circulation Models; a mesoscale model with wide applications for Earth and Mars), and in micrometeorological flux and aerosol formation studies. The aerosol and micrometeorological groups belong to the Research Unit on "Physics, Chemistry and Biology of Atmospheric Composition and Climate Change", which is one of the Centres of Excellence of the Academy of Finland. The main objective of the Unit is to study the importance of aerosol particles on climate change and on human health. Internationally, the Research Unit has a leading position in the research area of formation of atmospheric aerosols. The approach has started from basic nucleation theories and then followed up with detailed aerosol dynamic / atmospheric chemistry models and well defined laboratory experiments. Consequently, there are wide continuous field measurements on our research stations.

The aerosol group belongs to the Nordic Centre of Excellence "Biosphere-Aerosol-Cloud-Climate Interactions" (coordinator M. Kulmala) and the micrometeorology group to the Nordic Centre of Excellence "Nordic Centre for studies of ecosystem Carbon exchange and interactions with a Climate system" (coordinator A. Lindroth, Lund University). Both groups belong also to NorFA Graduate School "Carbon-Biosphere-Aerosol-Cloud-Climate Interactions".

A new international multi- and cross-disciplinary research project, "Integrated Land Ecosystem – Atmosphere Processes Study" (iLEAPS; <http://www.atm.helsinki.fi/ILEAPS/>) was established in March 2004 to study land-atmosphere interactions within the framework of the second phase of International Geosphere – Biosphere Programme (IGBP). IGBP is one of the four international global change research programs within the Earth System Science Partnership (ESSP). IGBP is sponsored, for example, by the International Council for Science (ICSU) through the national academies of science, and has 78 National Committees worldwide.

The iLEAPS project is led by a scientific steering committee of 18 scientists selected from the international environmental research community, and the international project office (IPO) is hosted by the University of Helsinki, Department of Physical Sciences. iLEAPS project aims to advance new integrated experimental and modelling research approaches needed in Earth System Science due to the complex dynamics of the Earth System.

The Division has direct working connections with more than 40 international laboratories and has participated in more than 20 EU projects. The Division has also direct connections with several Finnish research units and teams, e.g. the Departments of Chemistry and Forest Ecology (University of Helsinki), the Finnish Meteorological Institute, the Technical Research Centre of Finland, the Tampere University of Technology, the universities of Kuopio and Oulu, the Finnish Institute of Occupational Health, the Finnish Forest Research Institute and the European Forest Institute. These connections are established in a form common to both national and EU projects.

The Division of Atmospheric Sciences is in charge of all the meteorological university research and education in Finland. The international postgraduate training programme of aerosol and environmental physics, which was started in the beginning of the autumn semester in 1994, was continued in 2004.

Financial support from the Academy of Finland, the European Commission, Tekes, the Nessling Foundation, and the Väisälä Foundation is gratefully acknowledged.

Division of Geophysics

www.geophysics.helsinki.fi

Lauri J. Pesonen

The Division of Geophysics conducts basic research in the areas of solid earth and hydrosphere geophysics. Personnel consists of three professors, two assistants and some 15 research students. The Division has recently created two new laboratories in Physicum: the solid earth geophysics research laboratory and a laboratory for teaching solid earth geophysics.

In the Division, education covers the whole field of geophysics. In 2004 new courses have been developed and the curriculum now covers also global oceanography and marine modelling. Several field courses are arranged each year.

Geophysics investigates the Earth's natural conditions, which is basic research but does include applied aspects with respect to climate, environmental research or solid earth exploration.

Hydrosphere research activities are focussed on ice and snow, polar oceanography, lake physics and numerical ice and ocean modelling. Research areas are the Baltic Sea, the Sea of Okhotsk, Antarctica and the Antarctic marginal seas as well as Finnish and Estonian lakes. During 2004, studies on lake climatology, lake optics, sea ice dynamics and morphology, the snow conditions in Finland and Antarctica continued. New activities include the investigation of dense down slope currents in the ocean, Arctic sea ice vari-

ability (from observations and models) and the numerical investigation of aspects of marine ecosystems.

Data from the 1999/2000 and 2000/2001 Antarctic field campaigns were analyzed. One topic was the spatial variation in the albedo of snow and its relations to snow properties. Our *in situ* measurements of snow properties and albedo were compared to helicopterborne radiance measurements and satellite images. The results show that snow is optically very homogeneous in Antarctica. A third field campaign during the austral summer 2003/2004 included analysis of a series of snow pit measurements for snow stratigraphy and physical properties, short-wave radiation budget, and automatic snow stake data. An optical-microwave remote sensing programme is also ongoing. National collaboration with the Air Quality Research of the FMI analyses the chemical properties of the snow cover and the Antarctic snow research is collaboration with the University of Sherbrooke.

Ice measurements were carried out on lake ice and Baltic Sea ice. A platform with meteorological and ice and water temperature sensors and CT-current meter was deployed to Pääjärvi in November 2003 before onset of ice cover. The evolution of the ice cover was monitored during the whole winter. In the spring, before the ice-melting season, under-ice turbulence was measured for a week. In early March intensive ice cover and ice-water boundary salt and heat flux studies were carried out in the Umeå area.

Tiiu Elbra using the new superconducting SQUID-magnetometer.

Photo: Tomas Kohout



Ocean Modelling and the study of Marine Systems are a recent addition to the Division's scope of activities. The group expanded to one post-doc, one PhD student and one master student. Collaborations with the Finnish Institute of Marine Research FIMR and Finnish Environment Institute SYKE have been initiated. A "Polar Day" was organized to bring together all Finnish hydrosphere-cryosphere researchers.

A major step was the installation of the NEMO ocean modelling system on CSC's computer platforms. This was successfully completed in November. Since then, hindcast simulations of the past 50 years are being conducted.

A study funded by the Academy of Finland investigates the physical and dynamical properties of near-bottom currents in the ocean. These flows represent an important physical process for deep-water renewal and are of interest for both climate and ecosystem studies. The main tool for studying the dynamics is numerical modelling.

Marine ecosystems and their response to the physical environment were studied. The influence of the physical conditions on mesopelagic fish communities was studied at two seamounts in the North Atlantic. Also, the migratory behaviour of phytoplankton was modelled numerically, taking into account the internal quotas of energy and nutrients of the organisms. The results show that a large variety of observed patterns can be interpreted as the effect of varying sensitivity of different phytoplankton species to energy and nutrient depletion.

The solid earth group focuses on studies of supercontinents, impact cratering, meteorite and asteroid physical properties, the Earth's magnetic field and research of deep continental drill cores. The main topics in solid earth geophysics have been the study of the new Keurusselkä impact structure, the two lake Suvasvesi impact sites (forming a possible doublet), the Jänisjärvi impact, configuration of continents during the Proterozoic-Paleozoic times, the study of the physical properties of the Neuschwanstein and other meteorites and the estimation of the Earth's magnetic field in the past.

The highlight of the solid earth geophysics group was the installation of the new generation DC superconducting (SQUID) rock magnetometer in the solid earth geophysics research laboratory. The lab-

oratory is now fully equipped for high quality rock magnetic, paleomagnetic and petrophysics research.

The solid earth geophysics group participated in four international research programmes: the IGCP-440, the ESF-Impact Programme, the ICDP on continental drilling and the GISP-programme on impact research. Lauri Pesonen was the Finnish coordinator in all these projects.

Measurements of the intensity of the Precambrian magnetic field in an international collaboration, archeomagnetic intensity determinations of recent ceramics and bricks in collaboration with the National Board of Antiquities (Museovirasto) and several international university teams in the framework of the EU-based AARCH-programme were continued.

The IGCP-440 is concerned with the configuration of continents during the Precambrian and is based on a global paleomagnetic approach. Lauri Pesonen was nominated a co-leader in the new IGCP-project on "supercontinents", to be launched in early 2005.

The ESF-Impact project was concerned with studying the ages and petrophysics of impact structures in Finland, Russian Karelia, Ukraine, South Africa and Siberia. In 2004, the group started to investigate the new Keurusselkä impact structure. The field season was very successful and new shatter cones were found as boulders and also in outcrops.

The solid earth geophysics group took also part in searching a new ultrasonic technique to determine porosity of rock and meteorite samples. This work is collaboration with the Electronics Research Group of the Department.

The paleomagnetic studies of the Cambrian-Silurian period of Estonian sequences were continued in co-operation with the University of Tartu. Further paleomagnetic samples of both the 1.1 Ga diabase dykes in Arizona and of the 1.47 Ga diabase sills from Russian Karelia were collected.

The group continued to work in the ICDP-programme with samples from the 65 Ma old Chicxulub impact in Mexico to study its physical properties in the framework of the ICDP continental drilling project.

The main funding sources have been the Ministry of Education, the Academy of Finland, grants from the University of Helsinki, the European Science Foundation, EU, and several science foundations in Finland.

APPENDICES

The column diagrams presented have been drawn up according to the present Divisions of the Department of Physical Sciences although there were changes in the number and composition of Divisions in 2001 as the three departments, those of Physics, Meteorology and Geophysics were merged. Information has been collected from all the three departments and distributed according to the Divisions formed in 2001.

ADMINISTRATION

All the important University elections were arranged in the end of 2003 and the new members of the ruling administrative bodies of the University have functioned in their positions of confidence for the whole year 2004. Three persons from the Department were selected to the newly structured 15-member Senate. One of them is in the professorial section, one in the group of other personnel and one in the group of students. Of the 26 members of the Faculty Board there are 7 members representing the personnel and students of our Department; among the 12 professors of the Faculty Board there are 4 professors from our Department, in the 7-member group of the other personnel there are two of our representatives and among the students there is one of our departmental students. The expertise of our Department is hence present more strongly than before in the Senate and the Faculty Board.

The Departmental Board

The Departmental Board consists of fourteen principal members and twelve vice members. Four are professors, four belong to the teaching and other personnel group, four are students and two persons are elected from outside the University.

Professor Juhani Keinonen continued as the chairman of the new Board, and the members of the Departmental Board were (with vice members in parentheses):

Prof. Masud Chaichian (Prof. Kari Enqvist)
Prof. Keijo Hämäläinen (acting Prof. Seppo Manninen)
Prof. Juhani Keinonen (chairman) (Prof. Lauri Pesonen)

Prof. Markku Kulmala (vice chairman till 15.9.) (Prof. Timo Vesala)
Prof. Heimo Saarikko (vice chairman from 16.9.) (Prof. Timo Vesala)

BSc Raimo Ingren (Lab. Eng. Kim Wahlström)
Doc. Ismo T. Koponen (Dr. Ari Hämäläinen)
Doc. Hannu Kurki-Suonio (Doc. Katri Huitu)
Doc. Kari Lehtinen (MSc Kai Rasmus) till 31.8.
MSc Kai Rasmus (MSc Miikka Dal Maso) from 1.9.

Student Tiina Kilpeläinen (Student Teresa Tenhunen)
Student Eija Laatikainen (Student Olli Heino)
Student Jussi Polvi (Student Elina San)
Student Maaria Tervo (Student Elisa Piispa)

Vice Chief Director, Prof. Mikko Alestalo, Finnish Meteorological Institute
Director, MSc Ari Sipilä, Technology Industries of Finland

Dr. Aino Vahvaselkä continued to function as the secretary of the Board.

Administrative posts at University and Faculty level

Professor Juhani Keinonen was a member of the Senate, and university lecturer, Docent Björn Fant was also a member of the Senate in the quota for non-professorial representatives of teaching and research. MSc Walter Rydman was a member of the Senate in the quota for students.

The Department had the following members on the Board of the Faculty of Science:

Prof. Keijo Hämäläinen (Prof. Risto Orava)
Prof. Juhani Keinonen (Prof. Jyrki Räisänen)
Prof. Markku Kulmala (Prof. Kaarle Hämeri)
Prof. Heimo Saarikko (Prof. Hannu Koskinen)
Lab. Manager Merja Blomberg (BSc Raimo Ingren)
Academy researcher Hanna Vehkamäki (Doc. Claus Montonen) (Student Leila Konkola)
Student Harri Waltari

RESOURCES

Funding

Outside funding is still at a level of vital importance for the Department's research and teaching activity. Funding according to the model adopted by the University, basic budget funding, formed 53% of the whole funding of the Department; separate projects within the University contributed 1%, funds carried over from 2003 made up 6% and outside funding 40%. The resources acquired via the financing of various projects supported both an essential part of the research of the Department and, to a significant extent, its educational program. The rent for the premises of the Department of Physical Sciences was 1.96 M€. This sum is not included in the figures for funding.

Comprehensive budget funding for 2004 was 6.08 M€, 1.94 M€ of which was allocated for research and teaching equipment and for running costs, 4.14 M€ for salaries. The Department obtained 4.55 M€ from outside funds. Over half of it (52%) was granted by the Academy of Finland and the rest acquired from many different sources, the most important of which were Tekes, EU, and foundations.

Technical Support

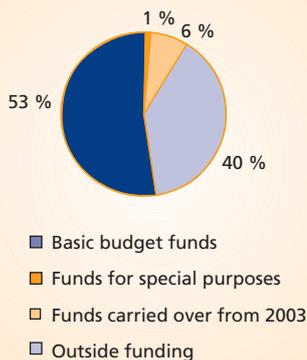
The workshops of the Department have continued to provide high-level support for research, development and teaching.

Computing facilities

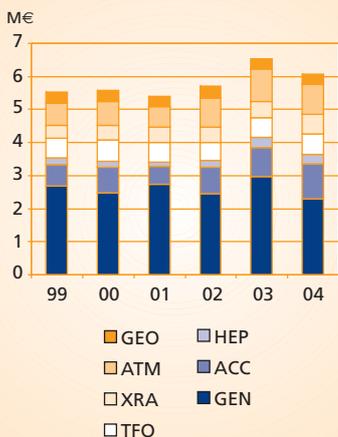
The backbone of all the computing at the Department is the extended Local Area Network of the University. This network connects all desktop computers and terminals with centrally supplied resources such as e-mail connections, mainframes, printers and Network servers. The Department has altogether approximately 500 PC computers, 20 Macintosh computers and 20 laser printers.

In the Accelerator Laboratory in Kumpula researchers and technical staff are served by about 90 computers. The laboratory has one server computer running a Linux operating

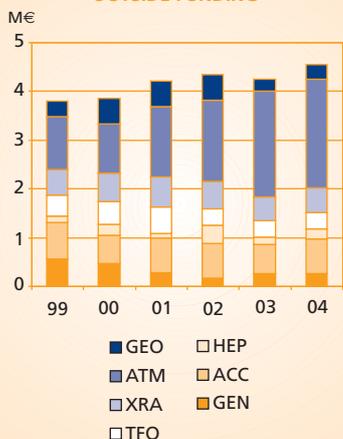
TOTAL FUNDING (11.50 M€)



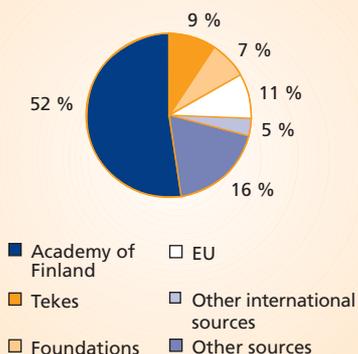
BUDGET FUNDS



OUTSIDE FUNDING



OUTSIDE FUNDING NOT IN THE UNIVERSITY BUDGET (4.55 M€)



system which acts as a file server for both Linux and NT Windows workstations and also runs many of the scientific programs the researchers use.

In 2004 the Department, together with the department of chemistry and HIP purchased and installed a 132-processor AMD Opteron Linux cluster computer "ametisti", which at the installation time is the second-fastest computer in Finland, running at a peak capacity of 530 Gflops. The 64-processor AMD Linux cluster "mill" purchased in 2003 (peak capacity 270 Gflops) was in regular production use in 2004. Both clusters are connected to the NorduGRID and thus put the Kumpula campus area in the forefront of GRID computing in Finland.

The department also hosts a 16 workstation Alpha Linux cluster "dynamo" and a Linux/Mosix cluster "moonshine" which utilizes idle time (evenings, nights and weekends) of about 30 researcher work station of the Accelerator laboratory. Taken together, these clusters give an excellent environment for high-performance computing at the Department. Applications needing specialized software or run in a massively parallel environment are performed at the National Center for Scientific Computing (CSC).

The Division of Atmospheric Sciences has about 100 personal or portable computer workstations for the use of research personnel. About 30% of our workstations are running Linux, and the rest are running different flavours of MS Windows. However, the number of Linux installations on our workstations is increasing all the time. In addition to workstations, dozens of our computers are tailored and continuously used for collecting data from different kinds of measuring instruments. Such instruments are e.g. the weather radar and the weather station in Kumpula, the local Meteostat receiver and instruments in SMEAR I, II and III stations in Väriö, Hyytiälä and Kumpula.

Our measurement computers have been used successfully in numerous measurement campaigns from Arctic Ocean to Antarctica, and from ground level to lower stratospheric altitudes. A dozen computers are running Linux and providing different services for our workstations at the Division. Such services are e.g. file, printing, backup, database and www services. The University Computing Centre frequently backs up the most important servers on tape. For the meantime, our most resource intensive computing needs, such as weather forecast modeling, are fulfilled by the Center for Scientific Computing. In the future, some of the less resource intensive computations could be performed at the joint Linux cluster of our Department and HIP joint Linux

cluster. We are also using a division level low performance Linux/Mosix cluster for numerical model development use only.

Personnel

During the year there have been the following changes in the personnel. Professor Pekka Suortti retired in the beginning of the year, Jyrki Kuikka was appointed to the part time chair of medical physics, and Ritva Serimaa was appointed to the chair of experimental soft condensed matter physics. Ritva Serimaa is the first female professor in our Department. Professor Markku Kulmala is on leave of absence during the following five years consequent upon his nomination as an Academy professor with the Academy of Finland. Esko Keski-Vakkuri, Ismo Koponen, Antti Kuronen. Kari Lehtinen and Rami Vainio commenced in their duties as university lecturers, Ismo Napari as a doctoral assistant and Szabolcs Galambosi, Jonna Koponen, Kristoffer Meinander, Kenichiro Mizohata, Sami Niemelä, Vesa Palonen and Marko Peura duties as assistants. Kai Nurminen started as a laboratory technician and Pasi Aalto as a laboratory manager. Senior researcher Nils Törnqvist retired.

The development of the job structure and the adjustment of the number of jobs to match the economical resources have resulted in the termination of 15 positions. Due to changes in job descriptions and the development of job structure 11 new positions have been created.

Research personnel supported by supplementary funding still continues to be a vital contribution to the functioning of the Department. By the end of the year there were 94 positions in the Department financed by internal university funding but about 250 persons were paid by supplementary funding. The total number of person-years in the Department was about 239.9, which is slightly more than in 2003.

The personnel of the Department is listed below. In 2004 a total of 80.8 person-years were financed by internal university funding. In the Department of Physical Sciences four departmental professorships were partially financed by other institutes. One was financed 45% by the Finnish Meteorological Institute FMI, another 45% by the Helsinki Institute of Physics HIP, another post financed one third by the Department of Biosciences and one third by the Institute of Biotechnology and a fourth post financed 50% by the Finnish Institute of Occupational Health. Two of the professors were financed through the pool of the Helsinki University professors. Due to the ongoing changes in the

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structure of the teaching personnel all posts could not be kept filled during 2004. There were 27 professors (21.8 person-years) and 19.4 person-years in other senior teaching posts. There were additionally 8.8 person-years in assistant posts for guiding laboratory practicals and problem sessions. The number of person years in principally administrative posts on the staff was 12.6 and that of technical employees 18.2, in all 30.8 person-years.

Outside funding supplied the financial basis for 159.1 person-years in 2004. This included senior and junior researchers of the Academy of Finland, post-graduate students in the GS (graduate school) program, researchers financed via the EU and researchers on other projects financed by both private and state funds.

Thirteen students were chosen to work outside the Department as summer trainees on separate funds. About 5.2 person-years were financed by the funds allocated to fee-for-service teachers.

Personnel 2004

(ol = on leave; This means paid by outside funds or physically absent for any reason.

Doc. = Docent i.e. Adjunct Professor
mo = months)

Head of Department
Keinonen, J., prof.

Professors

(annual total 21.8 person-years)

Annala, A.
Beckmann, A.
Chaichian, M.
Cronström, C.
Enqvist, K.
Hoyer, P.
Hämeri, K.
Hämäläinen, K.
Kajantie, K.
Keinonen, J.
Koskinen, H.
Kuikka, J., from 1.8., ol
Kulmala, M., ol 1.8.-31.12., locum
Prof. P. Wagner 1.9.-31.10.
Leppäranta, M.
Nordlund, K.
Orava, R., ol 15.4.-14.9.
Pesonen, L.
Riska, D.O., ol, locum Doc. T. Ahlgren
Räisänen, J.
Saarikko, H.
Savijärvi, H.
Serimaa, R., from 1.9.
Vesala, T.
1 vacancy till 31.8., locum Doc. R. Serimaa 1.-31.8.
1 vacancy, locum Doc. S. Manninen
1 vacancy, solid state electronics

University lecturers, doctoral assistants and assistants

(annual total 28.2 person-years)

University lecturers
(annual total 14.9 person-years)
Ahlgren, T., Doc., ol
Bister, M., Doc., ol, locum 1.1.-31.7.
Dr. J. Rinne, 1.8.-31.12. Dr. A. Bogdan
Fant, B., Doc.
Huitu, K., Doc., ol, locum 1.1.-31.8.
PhD A. Kobakhidze
Hægström, E., Doc., ol 15.6.-31.12.
Hämäläinen, A., Dr.
Keski-Vakkuri, E., Doc., ol, locum,
Doc. C. Montonen
Koponen, I.T., Doc.
Kurki-Suonio, H., Doc.
Kuronen, A., Doc., ol 1.1.-31.7.
Lehtinen, K., Dr. Tech., Doc., ol 1.8.-
31.12., locum Doc. I. Napari
Manninen, S., Doc., ol, locum 1.1.-
31.7. Dr. J. Laukkanen
Niskanen, J., Doc.
Rauhala, E., Doc.
Räisänen, Jouni, Doc.
Serimaa, R., Doc., till 31.8., ol 1.-31.8.,
locum Dr. M. Torkkeli
Vainio, R., Doc., from 1.8.
Österberg, K., Dr.
1 vacancy from 1.9., locum Dr. M. Torkkeli

Doctoral assistants

(annual total 4.5 person years)

Arstila, K., Dr., till 31.7.
Markkanen, T010., Dr., from 1.11.
Napari, I., Doc., ol 1.8.-31.12.
Sajavaara, T., Dr., ol, locum PhD P. De Almeida
Soininen, Aleks, Dr.
Torkkeli, M., Dr., till 31.7.
Vainio, R., Doc., till 31.7.

Assistants

(annual total 7.0 person years)

Donadini, F., MSc
Galambosi, S., MSc, ol 7 mo
Koponen, J., MSc, ol 6 mo
Meinander, K., MSc
Mizohata, K., MSc
Niemelä, S., MSc, ol 11 mo
Palonen, V., MSc
Peura, M., MSc
Rasmus, K., MSc

Assistants in locum positions

(annual total 1.8 person years)

Kauhanen, J., MSc, 10 mo
Porra, L., MSc, 6 mo
Salmela, A., MSc, 6 mo

Supportive administrative and technical staff

(annual total 30.8 person-years)

Technical personnel

(annual total 18.2 person-years)

. Laboratory managers
Aalto, P., Dr., from 1.5.
Blomberg, M., Doc.
Paatero, P., Doc., ol, locum MSc J. Hienola
Puhakka, T., Doc.
Ståhlberg, B., Doc.
Tikkanen, P., Doc.
Vikberg, S., MSc
Wahlström, K., eng.

. Other technical staff

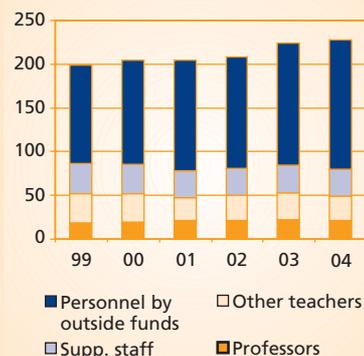
Engström, P., laboratory technician
Ingren, R., BSc, lab. techn.
Kortesmaa, J., general techn., till 31.3.
Kousa, S., eng., lab. techn., till 30.9.
Kurki, M., lab. techn., 6 mo
Nurminen, K., lab. techn.
Pekki, I., lab. techn.
Pihkala, P., lab. technician
Sariola, S., laboratory techn.
Sepponen, H., chief technician
Siiki, P., lab. techn.
Torp, F., lab. techn.

Administrative personnel

(annual total 12.6 person-years)

Ahonen, J., MSc, senior secretary
Andersson, S., Lic. Phil., amanuensis
Antila, U., senior secretary
Hyvönen-Dabek, M., Doc., aman.
Kivinen, M., senior secretary
Koivisto, L., senior secretary
Laitinen, M., MSc, aman.
Louhio, M.-L., senior secretary
Montonen, C., Doc., aman., ol, locum
1.1.-30.6. MSc T. Raita, 1.10.-31.12. Dr. C. Helminen
Pitkänen, T., senior secretary
Sundius, T., Doc., aman.
Uurinmäki, S., senior secretary, ol
9.11.-31.12.
Vahvaselkä, A., Dr., aman.

PERSONNEL



Personnel supported by external funds

(annual total 159.1 person-years)

General Division

(annual total 13.6 person-years)

. Didactical Physics Unit

(annual total 5.6 person-years)

Bressan, B., Dr., 2 mo

Hannula, I., MSc, 12 mo

Hendolin, I., student, 8 mo

Hoffren, H., student, 1 mo

Kallunki, V., Lic.Phil., 5 mo

Kirkkala, S.-R., MSc, 2.3 mo

Lintinen, S., student, 6 mo

Lehtonen, née Miettinen, S., MSc, 12 mo

Mäntylä, T., MSc, 12 mo

Vainikainen, M., student, 3 mo

Vuorialho, S., MSc, 4 mo

. Electronics Research Unit

(annual total 2.6 person-years)

Karppinen, T., Lic. Phil., 12 mo

Kassamakov, I., PhD, 6 mo

Lassila, I., student, 5.5 mo

Leppänen, M., student, 1.5 mo

Vihinen, P., student, 6 mo

. Medical Physics

(annual total 1.5 person-years)

Heikkinen, S., Doc, 9 mo

Karila, J., MSc, 3 mo

Koivunoro, H., MSc, 2 mo

Schenkel, Y., MSc (tech), 3 mo

Timonen, M., MSc, 1 mo

. Space Physics

(annual total 3.3 person-years)

Honkkila, V., MSc, 12 mo

Huttunen, E., MSc, 12 mo

Laitinen, Tiera, MSc, 12 mo

Sandroos, A., student, 3 mo

. Theoretical Nuclear Physics

(annual total 0.7 person-year)

Helminen, C., Dr., 8 mo

Accelerator Laboratory Division

(annual total 18.8 person-years)

Alakoski, E., MSc, 8 mo

Arstila, K., Dr., 5 mo

Björkas, C., student, 3 mo

Edelmann, E., MSc, 5.7 mo

Fordell, Th., MSc, 12 mo

Frantz, J., Dr., 7 mo

Harjunmaa, A., MSc, 12 mo

Heinola, K., MSc, 12 mo

Henriksson, K., MSc, 12 mo

Juslin, N., student, 5 mo

Kiili, P., MSc, 5 mo

Kiuru, M., Dr., 9 mo

Koskelo, O., student, 3 mo

Kotakoski, J., MSc, 12 mo

Krashennikov, A., PhD, 12 mo

Laitinen, P., Dr., 7 mo

Lehtinen, O., student, 3 mo

Lindberg, Å., Doc., 12 mo

Nord, J., Dr., 3 mo

Pomoell, J., student, 3 mo

Pusa, P., Dr., 10.8 mo

Sajavaara, T., Dr., 12 mo

Smolander, T., student, 3 mo

Tarus, J., Dr., 8.3 mo

Tiainen, V.-M., Dr., 12 mo

Träskelin, P., MSc, 12 mo

Valling, S., MSc, 12 mo

Väyrynen, A., student, 4 mo

High Energy Physics Division

(annual total 7.7 person-years)

Aschieri, P., PhD, 1 mo

Carey, A., Prof., 1 mo

Eggert, K., Prof., 0.2 mo

Honkavaara, T., MSc, 6 mo

Järvi, T., student, 2 mo

Järvinen, M., MSc, 12 mo

Khalil, S., PhD, 1 mo

Kochan, D., MSc, 6.5 mo

Kulish, P., Prof., 0.3 mo

Laamanen, J., MSc, 5 mo

Linnyk, O., MSc, 1 mo

Mnatsakanova, M., PhD, 2 mo

Mäki, T., MSc (tech), 5 mo

Nishijima, K., Academician, 1 mo

Peigné, S., PhD, 0.7 mo

Presnajder, P., Prof., 9 mo

Roy, P., PhD, 1 mo

Rüppell, T., MSc, 1 mo

Salmi, L., MSc (tech), 2.5 mo

Saxell, S., student, 3 mo

Tiitola, P., student, 3 mo

Tureanu, A., Dr., 12 mo

Törnqvist, N.A., Doc., 6 mo

Van Remortel, N., PhD, 8 mo

Vernov, Yu., Prof., 2 mo

Wess, J., Prof., 0.3 mo

Theoretical Physics Division

(annual total 13.2 person-years)

Adzhemyan, L., Prof., 2.8 mo

Antonov, N., DSc, 2 mo

Gynther, A., MSc, 12 mo

Heikkilä, V., student, 6 mo

Hietanen, A., MSc, 12 mo

Honkkila, V., MSc, 12 mo

Huovinen, P., Dr., 2 mo

Julia-Diaz, B., PhD, 6 mo

Keihänen, E., Dr., 12 mo

Kim, T., PhD, 2.8 mo

Komarova, M., MSc, 3 mo

Kompaniets, M., MSc, 1.4 mo

Koponen, J., MSc, 6 mo

Kurkela, A., student, 3 mo

Lappi, T., MSc, 12 mo

Lehtola, Jussi, student, 2.5 mo

Långvik, M., student, 2 mo

Mether, L., student, 3 mo

Muhonen, V., MSc, 6 mo

Nalimov, M., DSc, 3.3 mo

Novikov, S., PhD, 0.8 mo

Pirola, P., MSc, 12 mo

Pismak, Yu., DSc, Prof., 0.5 mo

Salmela, A., MSc, 6 mo

Strickland, M., PhD, 2 mo

Tahkokallio, T., student, 3 mo

Vepsäläinen, M., MSc, 12 mo

Vuorinen, A. Dr., 2 mo

Väliiviita, J., MSc, 6 mo

Vänskä, O., student, 2.8 mo

X-ray Division

(annual total 16.1 person-years)

Fernández, M., MSc, 12 mo

Hakala, M., Dr. Tech., 12 mo

Hyvönen, H., student, 1 mo

Ikonen, T., MSc, 12 mo

Jääskeläinen, P., student, 1 mo

Keyriläinen, J., MSc, 0.4 mo

Kisko, K., MSc, 12 mo

Koponen, T., student, 12 mo

Laukkanen, J., Dr., 5 mo

Liimatainen, T., student, 3 mo

Louhelainen, J.-M., student, 4 mo

Louhivuori, M., MSc, 12 mo

Mattila, A., MSc, 12 mo

Nygård, K., MSc, 12 mo

Pirkkalainen, K., student, 6.8 mo

Porra, L., MSc, 6 mo

Pylkkänen, T., student, 7 mo

Rantanen, M., MSc, 12 mo

Sarén, M., MSc, 12 mo

Suhonen, H., MSc, 12 mo

Suortti, P., Prof. emer., 10 mo

Vainio, U., MSc, 12 mo

Väänänen, T., MSc, 2 mo

Würtz, P., student, 3.5 mo

Division of Atmospheric Sciences

(annual total 69.2 person-years)

Aalto, P., Dr., 4 mo

Aarflot, A., MSc, 2.5 mo

Airaksinen, S., student, 1 mo

Altimir Escala, N., MSc, 12 mo

Anttila, P., student, 12 mo

Aura, A., student, 2 mo

Berg, Th., student, 3 mo

Bergman, T., student, 6.5 mo

Bogdan, A., Dr., 7 mo

Bonn, B., MSc, 2 mo

Boy, M., Dr., 12 mo

Bäck, J., Doc., 4.8 mo

Dal Maso, M., MSc, 12 mo

Ehn, M., student, 6.5 mo

Eneroth, K., student, 7 mo

Fiedler, V., 3 mo

Gagné, S., 3.5 mo

Gaman, A., MSc, 12 mo

Grönholm, T., MSc, 12 mo

Haapanala, S., MSc Tech, 9.8 mo

Haarlas, T., student, 3 mo

Hamed, A., MSc, 8 mo

Hannuniemi, H., student, 3 mo

Hellinen, T., student, 3.5 mo

Herrmann, E., MSc, 12 mo

Hiltunen, V., MSc, 12 mo

Hirsikko, A., student, 8.5 mo

Huotari, J., student, 11 mo

Hussein, T., MSc, 12 mo

Hölttä, T., MSc, 12 mo

Hörrak, U., PhD, 12 mo

Järvi, L., student, 3 mo

Jylhä-Ollila, A., student, 6 mo

Kaija, H, student, 1 mo
Kalakoski, N., student, 8 mo
Kalland, A., student, 4 mo
Kauhanen, J., MSc, 2 mo
Keronen, P., MSc, 12 mo
Koponen, I.K., Dr., 10 mo
Korhonen, H., Dr., 3 mo
Korhonen, J., student, 3 mo
Kulmala, Markku, Acad. prof., 5 mo
Kulmala, Mikko, student, 4.5 mo
Kuuspalo, K., MSc, 6 mo
Kyrö, E.-M., student, 3 mo
Laakso, H., eng., 8 mo
Laakso, L., Dr., 12 mo
Laitinen, Totti, student, 6.5 mo
Launiainen, S., student, 12 mo
Lauri, A., MSc, 12 mo
Lehtipalo, K., student, 3 mo
Leskinen, M., MSc, 12 mo
Ljungberg, K., student, 3 mo
Lushnikov, A., Prof., 12 mo
Lyvbotseva, Yu., 1 mo
Makkonen, R., student, 6 mo
Manninen, H., student, 3 mo
Markkanen, T., Dr., 10 mo
Martikainen, J., student, 12 mo
Massling, A., PhD, 5 mo
Merikanto, J., MSc, 11 mo
Mordas, G., Dr., 12 mo
Mäkynen, J., Lic. Tech., 1 mo
Määttänen, A., MSc, 12 mo
Niemi, J., MSc (Agro For), 3.8 mo
Niemi, S., student, 7.5 mo
Noppel, M., PhD, 12 mo
Nousiainen, T., Dr., 3 mo
Olin, M., Doc., 4 mo
Paatero, P., Doc., 12 mo
Peltomaa, E., student, 6 mo
Petäjä, T., MSc, 12 mo
Pihlatie, M., MSc (Agro For), 12 mo
Pimenoff, N., student, 5 mo
Pirazzini, R., Lic.Phil., 12 mo
Pumpanen, J., MSc (Agro For), 10 mo
Puttonen, E., student, 3 mo
Puustinen, A., MSc, 12 mo
Pystynen, K.-H., student, 7 mo
Raivonen, M., student, 2 mo
Rannik, Ü., Doc., 4.5 mo
Reissell, A., Dr., 12 mo
Riipinen, I., student, 11.5 mo
Rinne, J., Dr., 5 mo
Ruokolainen, L., student, 5 mo
Ruuskanen, T., MSc, 12 mo
Salonen, M., student, 12 mo
Sevanto, S., Dr., 8 mo
Sihto, S.-L., MSc (Tech), 12 mo
Siivola, E., MSc (Tech), 12 mo
Silvan, N., student, 3.9 mo
Sipilä, M., student, 3.5 mo
Sogachev, A., PhD, 9 mo
Sorjamaa, R., MSc, 3 mo
Sundström, née Sumujärvi, A.-M., MSc, 12 mo
Suni, T., Dr., 11 mo
Taipale, R., student, 8.5 mo
Tisler, P., Lic.Phil., 12 mo
Torpo, L., Dr. Tech., 7 mo
Vana, M., PhD, 12 mo
Vartiainen, E., student, 12 mo
Vehkamäki, H., Doc., 12 mo
Wagner, R., 1.8 mo

Winkler, P., MSc, 7 mo
Zapadinsky, E., Dr., 4 mo
Zilitinkevich, S., Prof., 8 mo

Geophysics Division (annual total 10.5 person-years)

An, B.W., PhD, 3 mo
Elbra, T., MSc, 12 mo
Cheron, A., student, 3 mo
Granskog, M., Dr., 1 mo
Hämäläinen, T., 9 mo
Kalmi, M., student, 1 mo
Kangas, A., student, 0.4 mo
Kanto, née Kärkäs, E., MSc, 12 mo
Kianne, P., MSc, 7 mo
Kiema, J., eng, 6 mo
Kohout, T., MSc, 11 mo
Lindfors, A., MSc, 4 mo
Luodekari, K., student, 2 mo
Mattila, O.-P., student, 4 mo
Rasmus, S., MSc, 8 mo
Salminen, J., MSc, 12 mo
Seppälä, T., Msc (Tech), 2 mo
Suomi, I., MSc, 12 mo
Tähtinen, M., Lic. Tech., 2 mo
Uusikivi, J., MSc, 8 mo
Wang, K., MSc, 7 mo
Wang, C., MSc, 2 mo

Teachers from other institutions

(The teachers paid by a supplementary teaching budget have given a full course.)

Aaltonen, J, Lic Phil, Helsinki Institute of Physics HIP
Ahtee, M, Prof. emerita, University of Jyväskylä
Airo, M-L, Dr Tech, Doc.
Amm, O, Doc, Finnish Meteorological Institute FMI
Eloranta, E H, PhD, Radiation and Nuclear Safety Authority Finland STUK
Hari, P, Prof, Department of Forest Ecology
Heikkinen, P, Dr, Director, Institute of Seismology
Heikkinen, J, Doc, Helsinki University Central Hospital HUCH
Honkonen, J, Doc, National Defence College
Huttula, T, Doc, Environmental Consulting
Hyvönen, T, Lic. Phil., Institute of Seismology
Kahma, K, Doc, Finnish Institute of Marine Research FIMR
Koistinen, J, MSc, FMI
Korja, A-K, Doc, Institute of Seismology
Kupiainen, A, Acad Prof, Department of Mathematics and Statistics
Kurki-Suonio, K, Prof. emer.
Kärkkäinen, L, Doc, Nokia Research Center
Myrberg, K, PhD, FIMR
Ollikainen, M, Dr, Finnish Geodetic Institute

Pasanen, Ossi, MSc
Peltoniemi, M, Prof, Helsinki University of Technology HUT
Poutanen, M, Prof, Finnish Geodetic Institute
Riekkola, M-L, Prof, Department of Chemistry
Saarelainen, S, Doc, VTT (Technical Research Centre of Finland)
Savolainen, S, Doc, HUCH
Smolander, S, MSc, Rolf Nevanlinna Institute
Tuma, R, Doc, Institute of Biotechnology
Vermeer, M, PhD, Prof, HUT
Vihma, T, Doc, FIMR
Viljanen, A, Dr, FMI
Wallin, A., MSc

RESEARCH

Publications

Peer reviewed articles

In 2004 the personnel of the Department of Physical Sciences published 254 articles in esteemed scientific journals with international peer reviewing systems. A complete list of these publications is given here below. The publications are grouped according to our main research fields. The number of publications in materials and related applied physics was 72, atmospheric sciences 61, particle, mathematical and nuclear physics 75 and didactical physics, electronics, medical and biophysics, geophysics and space physics 46.

Books

Professor Matti Leppäranta's textbook on The Drift of Sea Ice is intended for worldwide use. A new edition of "Elektroniikan perusteet" (Basic Electronics) appeared. The medical physics group published a guide for those intending to become hospital physicists.

Professor Kari Enqvist published a book called "Vien rucolan takaisin" (essays in Finnish).

Research Collaboration

The Department of Physics has wide collaboration with many foreign universities and research centres. During the 3-year period 2002–04 peer reviewed articles involved collaboration with scientists from 251 European institutes, 100 institutes in North and 2 in South America, 22 institutes in Asia, 2 in Australia, 3 in Israel, 1 in Africa and over 90 domestic ones. Scientists from the Department had also collaboration with 14 foreign and 12 domestic companies, giving rise to publications during this 3-year period. The CERN collaborations with large research groups are excluded.

Twenty-five foreign scientific visitors worked in the Department for longer than one month (altogether 51 months), 25 visited for more than two weeks (altogether 16 months) and 102 persons paid a shorter visit. Of the departmental staff 18 persons visited foreign research centres for periods longer than one month (altogether 34 months) and 11 people for more than 2 weeks (altogether 6 months). Detailed information about the visitors can be found from the University Data Base at <http://www-db.helsinki.fi/muti/>.

The research groups of the Department are in co-operation with tens of university departments in Finland (University of Helsinki, 42 laboratories and departments in 5 faculties, Helsinki University of Technology 14 laboratories, Technical Research Centre of Finland 9 departments, Universities of Jyväskylä, Kuopio, Oulu, Turku and Lapland, Tampere and Lappeenranta Universities of Technology, Åbo Akademi, about 20 other state or research institutes) and with research institutes in both physics and interdisciplinary research.

Collaboration with the Helsinki Institute of Physics (HIP), of which Prof. Juhani Keinonen is a board member, is being developed both in research and post-graduate education.

Conferences attended

There were 77 invited talks, 228 other oral presentations and 127 poster presentations in international conferences and 14 invited talks, 42 other oral presentations and 83 reports in domestic meetings. Detailed information about these can be found in the Helsinki University Knowledge Databases (<http://www-db.helsinki.fi/osaamistietokannat/index.shtml>).

Conferences organized

The second international Aerosol-Ion workshop was arranged in Helsinki 25. - 26.2.2004.

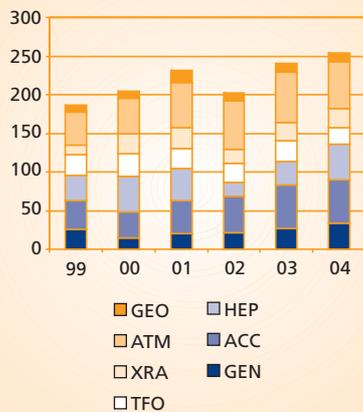
The workshop "From Nuclear to Nucleon Structure" was held 1. - 2.4.2004 to celebrate the 60th birthday of Prof. D. O. Riska.

A workshop on Organic Aerosols in Hyytiälä 10. - 12.5.2004 gathered 35 participants, 26 from abroad from 12 countries.

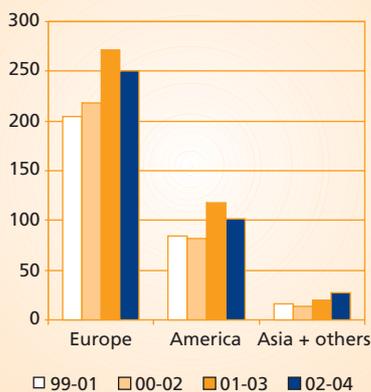
A meeting of the Mobility Committee of the EMSPS (European Physical Society Mobility Scheme for Physics Students) was held in Physicum 28. - 29.5.2004. University lecturer Jouni Niskanen hosted the meeting. He represents the Scandinavian and Baltic countries in EMSPS. This was the first time the meeting was held in Finland. In addition to the host there were eight participants, each from a different country.

The Planck Working Group 3 (CTP) Meeting was held 8. - 12.6.2004 in Physicum. Planck is a future CMB (Cosmic Microwave Background) space mission driven by the European space community. The Planck satellite will be launched in early 2007 and its data becomes available in 2007 - 2008.

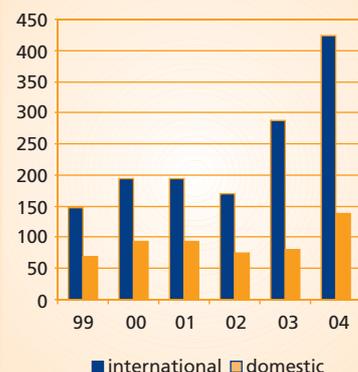
PEER REVIEWED PUBLICATIONS



COLLABORATION INSTITUTES



CONFERENCE CONTRIBUTIONS



Our Department together with the departments of Clinical Physiology and Oncology arranged a symposium "Advances in Imaging of Lungs and Breast Cancer by Synchrotron Radiation" in Biomedicum, Helsinki, 10. - 11.6.2004. The Symposium was sponsored by the Academy of Finland. There were participants from ESRF, University of Copenhagen, Helsinki University Central Hospital, Turku University Central Hospital, EMBL, Hamburg, WHO, Lyon, Lund University and the Canadian Light Source, Saskatoon.

The Division of Theoretical Physics arranged a conference called "Strong and Electroweak Matter 2004" in Physicum 16. - 19.6.2004. There were 39 participants from outside our Department.

COSIRES 2004, the 7th International Conference on Computer Simulation of Radiation Effects in Solids was organized in Physicum. This series of conferences, held biannually, addresses the development and application of advanced computer simulation techniques to the study of the interaction of energetic particles (from several eV to some MeV) with solids. The conference gathered about 110 participants from 25 countries.

The Caramel-Elena meeting 30. - 31.8.2004 was a small Finnish-Swedish workshop on physics and chemistry of carbon nanotubes. It brought together the people of two national nanotube-consortia, ELENA in Finland and CAMEL in Sweden as well many others interested in participating in the workshop.

Assistant professor Dan Maclsaac and lecturer Kathleen Falconer from SUNY-Buffalo State Colleges (New York, USA) visited the Department of Physical Sciences invited by the Didactical Physics Unit, on 16.8.2004. They held a workshop type seminar entitled "Reformed Teacher Observation Protocol (RTOP)".

The 4th NorFA Network Meeting on Particle Physics and Cosmology took place in Helsinki 9. - 10.9. 2004 in the Physicum building.

A seminar on the topic of "Condensation Phenomena" was organized at the Division of Atmospheric Sciences 16.9. - 15.10.2004. Prof. Paul E. Wagner from the University of Vienna was invited as a visiting lecturer.

An open Symposium belonging to the 5th Nordic Paleomagnetic Workshop Physicum was arranged on 30.9.2004. The topics of the Symposium were supercontinents, remagnetizations and geomagnetic modelling and it attracted about 30 foreign participants.

Published journal articles 2004

MATERIALS PHYSICS AND RELATED APPLIED PHYSICS

K. Nygård, S. Huotari, K. Hämäläinen, S. Manninen, T. Buslaps, N. Hari Babu, M. Kambara and D.A. Cardwell, Temperature dependence of MgB_2 Compton profiles, *Phys Rev B* 69 (2004) 020501 (R)

M. Hakala, S. Huotari, K. Hämäläinen, S. Manninen, Ph. Wernet, A. Nilsson and L.G.M. Pettersson, Compton profiles for water and mixed water-neon clusters: A measure of coordination, *Phys Rev B* 70 (2004) 125413

G. Döring, C. Sternemann, A. Kaprolat, A. Mattila, K. Hämäläinen and W. Schülke, Shake-up valence excitations in CuO by resonant inelastic x-ray scattering, *Phys Rev B* 70 (2004) 085115

S. Valkama, H. Kosonen, J. Ruokolainen, T. Haatainen, M. Torkkeli, R. Serimaa, G. ten Brinke and O. Ikkala, Self-assembled polymeric solid films with temperature-induced large and reversible photonic-bandgap switching, *Nature Materials* 3 (2004) 872-876

S. Manninen, Quantum crystallography: Electron density and bonding, a microsymposium, *Acta Cryst A* 60 (2004) 103

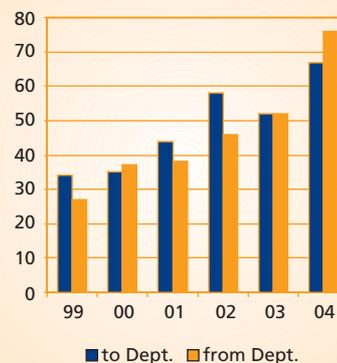
J. Psencik, T.P. Ikonen, P. Laurinmäki, M.C. Merckel, S.J. Butcher, R.E. Serimaa and R. Tuma, Lamellar organization of pigments in chlorosomes, the light harvesting complexes of green photosynthetic bacteria, *Biophysical Journal* 87 (2004) 1165-1172

T. Kallio, K. Kisko, K. Kontturi, R. Serimaa, F. Sundholm and G. Sundholm, Relationship between methanol permeability and structure of different radiation-grafted membranes, *Fuel Cells* 4 (2004) 328-336

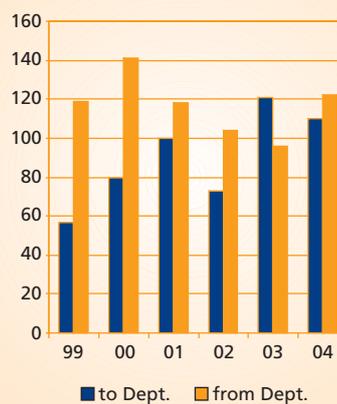
S. Huotari, K. Hämäläinen, R. Diamant, R. Sharon, C.-C. Kao and M. Deutsch, X-ray hypersatellite spectra of hollow atoms, *J Electron Spectrosc Relat Phenom* 137-140 (2004) 293-297

M. Deutsch, E. Förster, G. Hölzer, J. Härtwig, K. Hämäläinen, C.-C. Kao, S. Huotari and R. Diamant, X-ray spectrometry of copper: New results on an old subject, *J Res Natl Inst Stand Technol* 109 (2004) 75-98

VISITING SCIENTISTS



TOTAL LENGTH OF VISITS (months)



45

- M. Knaapila, K. Kisko, B.P. Lyons, R. Stepanyan, J.P. Foreman, O.H. Seeck, U. Vainio, L.-O. Pålsson, R. Serimaa, M. Torkkeli and A.P. Monkman, Influence of molecular weight on self-organization, uniaxial alignment, and surface morphology of hairy-rodlike polyfluorene in thin films, *J Phys Chem B* 108 (2004) 10711-10720
- J-P. Vidal, G. Vidal-Valat and K. Kurki-Suonio, Indicators of the magnetic state in the charge distributions of MnO, CoO and NiO, II Para- and Antiferromagnetism of CoO, *Kristallografiya* 49 (2004) 357-369, in Russian, *Crystallography Reports* 49 (2004) 422-434, in English
- U. Vainio, N. Maximova, B. Hortling, J. Laine, P. Stenius, L.K. Simola, J. Gravitis and R. Serimaa, Morphology of dry lignins and size and shape of dissolved kraft lignin particles by X-ray scattering, *Langmuir* 20 (2004) 9736-9744
- M. Tiitu, N. Volk, M. Torkkeli, R. Serimaa, G. ten Brinke and O. Ikkala, Cylindrical self-assembly and flow alignment of comb-shaped supramolecules of electrically conducting polyaniline, *Macromolecules* 37 (2004) 7364-7370
- S. Andersson, H. Wikberg, E. Pesonen, S.L. Maunu and R. Serimaa, Studies of crystallinity of Scots pine and Norway spruce cellulose, *Trees - Structure and Function* 18 (2004) 346-353
- M.-P. Sarén, R. Serimaa, S. Andersson, P. Saranpää, J. Keckes and P. Fratzl, Effect of growth rate on mean microfibril angle and cross-sectional shape of tracheids of Norway spruce, *Trees - Structure and Function* 18 (2004) 354-362
- K. Nygård, K. Hämäläinen, S. Manninen, P. Jalas and J.-P. Ruottinen, Quantitative thickness determination using x-ray fluorescence: application to multiple layers, *X-Ray Spectrom* 33 (2004) 354-359
- I.T. Koponen, M.O. Jahma, M. Rusanen and T. Ala-Nissila, Submonolayer Growth with Anomalously High Island Density in Hyperthermal Deposition, *Phys Rev Lett* 92 (2004) 086103
- P.O. Lehtinen, A.S. Foster, Yuchen Ma, A.V. Krasheninnikov and R.M. Nieminen, Irradiation-induced magnetism in graphite: A density functional study, *Phys Rev Lett* 93 (2004) 187202
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S. Savolainen, M. Kortensniemi, O. Sipilä, P. Nikkinen, J. Perkiö and M. Tenhunen, *Opinto-ohjeet sairaalafysiikoksi aikoville*, Report Series in Physics HU-P-A83, ISBN 952-10-1671-X, University of Helsinki 2004, 31 pages

EDUCATION

The number of ECTS (European Credit Transfer System) credits taken in the Department was 20,374 in 2004, which was 19.2% of all those taken in the Faculty of Science. (The study week concept, commonly used in Finland, is 1.5 ECTS credits.)

In 2004 38 students took their MSc degree in the Department. For the 5-year period 2000–04 the median age of those finishing their Master's degree was 26.1 years, half a year less than the median, 26.6 years, for the 5-year period 1995–99.

The proportion of women of those graduating from the Department in the 5-year periods 2000–2004, 1999–2003 in parentheses, were: MSc 32% (29%) and PhD 33% (28%). These similar proportions for PhD and MSc degrees indicate that the Department has to a great extent fulfilled its aim of equality of opportunity for women in researcher education. The mean proportion of women of those who started studying physical sciences in the years 1994–1998 was 32%.

In 2004 26 post-graduate students took the degree of Doctor of Philosophy and 4 the degree of Licentiate of Philosophy. In the period 2000–04 the median of the age distribution of the graduating doctors in the Department was 30.9 years, about half a year less than the median 31.4 years in the period 1995–99. The effort to shorten the time needed to accomplish a doctor's degree by increasing monitoring of student progress will still continue.

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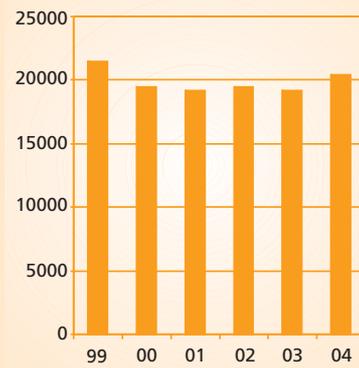
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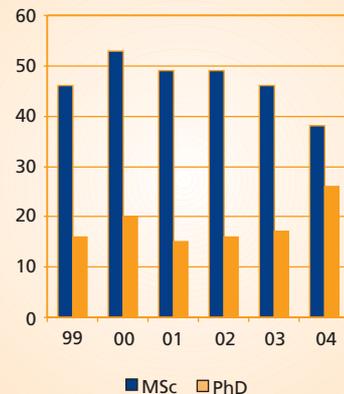
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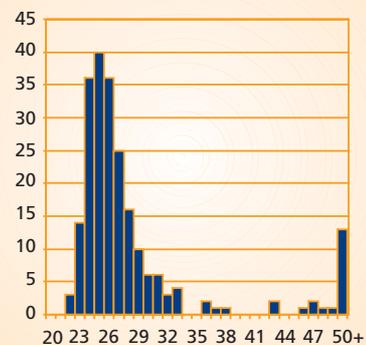
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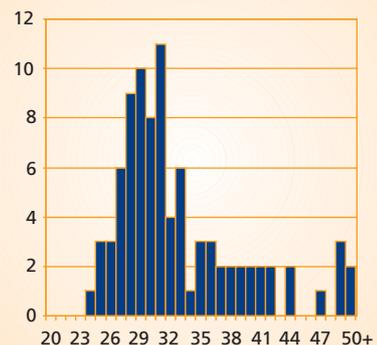
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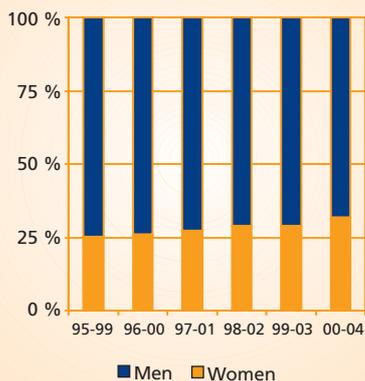
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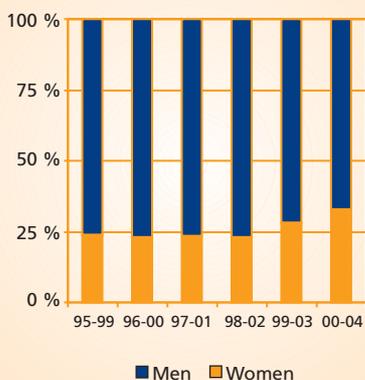
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