UNIVERSITY OF HELSINKI

DEPARTMENT OF PHYSICAL SCIENCES

# *Annual Report 2002*

The inauguration of the sculpture "Valo ja aine" on the main façade of the Physicum on September 9, 2002. Photo: Ari Vaskin

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# *Preface*

**In 2002 there has been a re-orientation in the functioning of the Department. Our new situation on the Kumpula campus has influenced our thinking about future developmental changes being realized in our new milieu. The Department has outlined its coming activities for the period 2004–2008 in a new strategy.**

Photo: Seppo Andersson

During the year, the Consistorium Major has made historical decisions regarding the administration of our University. These decisions will define a whole new administrative scope for our activities. The effects of the decisions have already started to direct our functioning in the development of a campus-based administration.

Changes in faculty structures connote the division of the current Faculty of Science into three new faculties from the beginning of 2004. The exact sciences (physical sciences, chemistry, mathematics and computer science) located on the Kumpula campus, together with geology and geography, will form a new Faculty of Science. The biological sciences located mainly on the Viikki campus will constitute a Faculty of Biosciences together with the Department of Limnology and Environmental Protection from the current Faculty of Agriculture and Forestry. The Department of Pharmacy will become the Faculty of Pharmacy. The administrative preparations regarding the functioning of these faculties have already been initiated. Also the preparations for the new administration and election regulations have gone so far that the motions will be brought before the Consistorium Major in the beginning of 2003.

During the passed year, there have been more changes at the professorial level than in previous years. Mauri Luukkala retired at the turn of the year, Timo Paakkari at the end of May and Kari Eskola at the end of August. The death of Professor Emeritus Mauri Luukkala during a sailing competition in the beginning of July came as sudden and shocking news. The Chancellor appointed Keijo Hämäläinen to the professorial post of experimental solid state physics from the beginning of September and Hannu Koskinen to the chair of space physics from the beginning of November.

Three professorial appointments were made in the autumn. Kaarle Hämeri was appointed to the chair of aerosol physics and Kai Nordlund to the pool professorship of computational physics from the beginning of 2003. The professorship of aerosol physics is maintained jointly by the Department of Physical Sciences and the Finnish Institute of Occupational Health. Jyrki Räisänen will occupy the chair of accelerator based experimental materials physics from February 2003.

According to the new job structure for teaching personnel, positions were filled in the beginning of the year by university lecturers Marja Bister in meteorology, Edward Haeggström in electronics, Ari Hämäläinen in teacher education, Kari Rummukainen in theoretical physics and Kenneth Österberg in experimental particle

physics. Fabio Donadini started in the position of assistant in the beginning of the year.

Marja-Liisa Louhio started in the position of departmental secretary from the beginning of the year and Ulla Antila as a secretary from May.

The structure of the personnel of our Department is still strongly coloured by the research personnel financed by outside funding which supports well over half of the personnel, about 127 person-years.

The construction of the Kumpula campus continued throughout the year. The building of both the Exactum, which also has premises for the Department of Physical Sciences, and the sports hall was begun in the second half of the year. The sports hall will be completed during the summer of 2003 and the Exactum in the spring of 2004. The commencement of the erection of the building for the Finnish Meteorological Institute and the Finnish Institute of Marine Research was finally scheduled for 2003. The collaboration with these research institutions will thus become stronger in 2005, as new neighbours. The preparations for the construction plans of the Kumpula stage V were initiated at the end of the year.

The Physicum building has been tuned to serve our needs even better during this year. Also some defects remaining from the construction have been fixed. The inauguration of the massive decorative sculpture "Valo ja aine" ("Light and matter") on the main façade of the Physicum at the opening of the autumn term marks a new phase in the identification of our Department giving it a symbolic identity in the constellation of physics departments in Finland and abroad.

During this year, the Department's research remained as productive as previously. In addition to established and active publishing, this is illustrated by the fact that the research group of the Division of Atmospheric Sciences achieved a Centre of Excellence status of the Academy of Finland and its two groups are visibly involved in two Nordic Centres of Excellence of research. Professor Markku Kulmala co-ordinates the Centre of Excellence "Research Unit on Biosphere–Aerosol–Cloud–Climate - Interaction" and Professor Timo Vesala is involved in the Centre of Excellence "Nordic Centre for Studies of Ecosystem Carbon Exchange and its Interactions with the Climate System". These Centres of Excellence also constitute a Nordic Graduate School, which is co-ordinated by Markku Kulmala.

On account of its substantial research activity the Department has maintained a high level of outside funding during the passed year which still constitutes 43 % of the Department's total funding. This outside funding has enabled the Department to keep up the versatile teaching and to develop research. The special funding for new research facilities, related to the strengthening of Physicum and very notable concerning our budget, has enabled significant equipment purchases and their preparations. New equipment and facilities have considerably enhanced our capacity to be productive in research.

The evaluation project of University teaching and degrees was completed during the year. The results of the evaluation significantly further facilitate the development of our teaching and co-ordination with the exact sciences at the campus. The results have already had an effect on preparing the ground for enhanced teaching during the coming years. Preparations for the new two-staged degree structure are conveniently dealt with during the same development project.

The architecture of Physicum conducive to interactions has effectively brought about not only teaching and research activity but also facilitated social activity in the joint celebrations of the whole campus. A ceremonial opening to the academic term and the inauguration of the new sculpture on the façade of the Physicum were celebrated in the beginning of September and an Advent Party was held at the end of November. These events have bonded together the Department of Physical Sciences with the other disciplines on the campus. As populous and successful events on the campus, staff parties have contributed to the creation and growing of a vivacious campus spirit.

*Juhani Keinonen*
Professor
Head of the Department

# Research

## LABORATORY OVERVIEWS

### General Division

The General Division consists of several units.

#### Teacher Training Unit

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

*Heimo Saarikko*

The main developments in didactical physics in 2002 can be summarized as follows: 1) study of learning processes based on the empirical–constructive approach, 2) increased international co-operation and 3) learning to utilize modern education technology.

The research activity in didactical physics has now found its path and methodology. The scattered research interests of previous years have been gathered together so that the efforts of disparate researchers are co-ordinated. There are now five areas of study:

1. Research on the conceptual understanding of mechanics has been continued and results on the standardized tests for assessing the conceptual understanding of physics have been reported. The project has continued with a study concentrating on the role of teachers' epistemology in instruction and in its approaches. This research is partially carried out in collaboration with the Department of Teacher Education, University of Helsinki and with Prof. C. Angell from the Department of Physics of the University of Oslo.
2. The conceptual understanding of quantum mechanics was investigated and a survey carried out in two advanced courses during 2000–2001. The research concentrated in constructing a picture of the students' conceptual understanding of quantum entities, with possible implications on university level teaching. This research is continued in research collaboration with the Department of Physics of the University of Joensuu.
3. Research on conceptual models in learning and teaching of electricity continues. This study attempts to find connections between what can be called teaching models and reasoning patterns and models learned by students. In this research methodological collaboration with Prof. Gutierrez (IEPS-institute, Madrid and University of Barcelona) is carried out, helping to develop the research methodology of our group.
4. A project intended to help teachers to manage with complexities of computer-based measurement systems has been continued, including a survey of difficulties in using ultrasonic distance sensors and a comparison test for two measurement systems. This is a co-operative project with Prof. MacIsaac (Buffalo State College).
5. Research in teaching astronomy in secondary schools, relying much on the instruments constructed by pupils has been advanced.

Development of teaching is strongly based on research. The focus has been on conceptual and processual structures of physics emphasizing constructive views on building up knowledge. The running theme is to support the development of content knowledge of teachers in their profession and integrate subject knowledge with didactical and pedagogical views. On this basis, development of different kinds of applications for all levels of physics instruction has been continued. Among other things, this includes developing and refining the courses of the teacher education programme, and planning courses for in-service training for both primary and secondary school teachers as well as development and adaptation of lecture demonstrations.

Other developments include exploring the use of real and virtual laboratories and simulations in physics teaching, as well as offering new workshop type courses in teacher training. Much emphasis has been laid on the development and renewing of the facilities of modern education technology, e.g. utilizing the Internet for web-based instruction and microcomputer-based laboratory systems. An interactive learning method was introduced for the lectures of this course. A web-based teaching experiment has been carried out, and more web-based material has been made available. The network-based interactive learning and discussion environment "WebCT" has been used in some courses. Intensive collaboration with the Faculty of Education of the University of Helsinki has continued in developing teacher training.

Extensive complementary education programmes in didactical physics (DFCL's, see Adult Education) have brought new practices of modern processual teaching and perceptional experimentality into everyday operation in many of the schools of the participants. All new theses are added in electronic form to the Network Thesis Library of Didactical Physics. The additions to the library are announced on the DFCL e-mail list, which has developed from a mere information channel of a complementary

training project to a national discussion forum of physics teachers. Supplementary training projects for in-service elementary school class teachers have been implemented as a new activity in co-operation with the Department of Chemistry and the Department of Teacher Education.

The Teacher Training Unit organised in Summer 2002 in co-operation with EAAE (European Association for Astronomy Education) organized the 6th International Summer School in Astronomy in summer 2002 in Enontekiö, Finland. The theme of the summer school was "The Midnight Sun". The course consisted of practical workshops, lectures, discussions and observations.

## Electronics Research Unit

www.physics.helsinki.fi/~fyl_etla

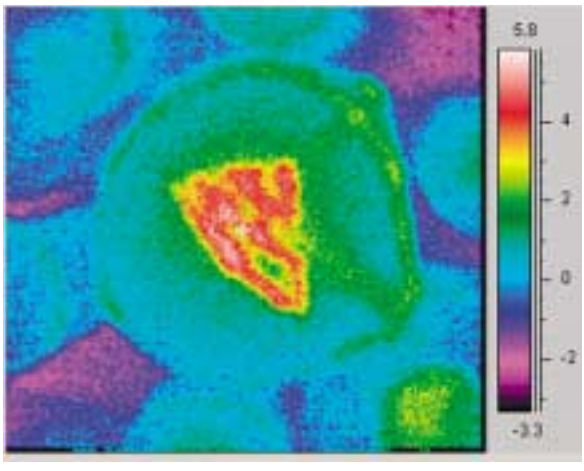
*Heimo Saarikko*

Development of different novel measurement methods and sensors using optics, ultrasonics and electronics combined continued. The most important programme during the year has been the final leg of the so-called TUKEVA-project (supporting new measurement methods in future machine construction technology) financed by the Academy of Finland. In this stage we improved the parameters of our coherence microscope, developed under this programme. The vertical resolution of the microscope is now in nanometers range and good quality images of the surface profiles of various samples can be obtained. A new device application – quality control of flexible single-point TAB interconnections, used in Silicon Strip Detector (SSD) modules for A Large Ion Collider Experiment (ALICE) at CERN – was found. Collaboration with industry led us to use a coherence microscope for the coefficient of thermal expansion (CTE) of microelectronics devices measurement.

During the year investigation of paper and paper coatings was continued. The wetting properties of different papers and coating materials were studied with optical methods. First we measured the change of intensity of laser light transmitted through paper during wetting. The results showed that by using our method it is possible to distinguish the capillary wetting in the pores of the paper and the diffusion of water into the fibres. In case of coating materials we used a high-speed charge coupled camera (CCD) for the wetting measurement with good results. These studies were managed in co-operation with the paper industry.

The elastic properties of the paper and its coating materials were also studied. Measurement of the elastic modulus of these materials is not possible by the traditional stretching method due to fragile samples. In these measurements we used the contact ultrasonic method. By this measurement method we achieved a determination of the elastic modulus of the samples in the direction of thickness. During this year we also investigated the photo-acoustic method for the same purpose. In the photo-acoustic method a short high-power laser pulse is applied on the sample surface, where the thermal expansion gives rise to an ultrasonic signal. The non-contact nature of this method enables a wide range of applications. So far the results have been very promising and we are continuing with this work in co-operation with the Laboratory of Physics of the Helsinki University of Technology.

Photo: Sari Luhtakanta




Infrared picture of the spruce log.

A proof of the versatility of our laboratory was our participation in the Metsäteho Oy project of cold-preservation of timber in the paper industry. Several measurements were performed in the field for example with an infrared camera, and a number of laboratory experiments were made to study the preservation of wood.

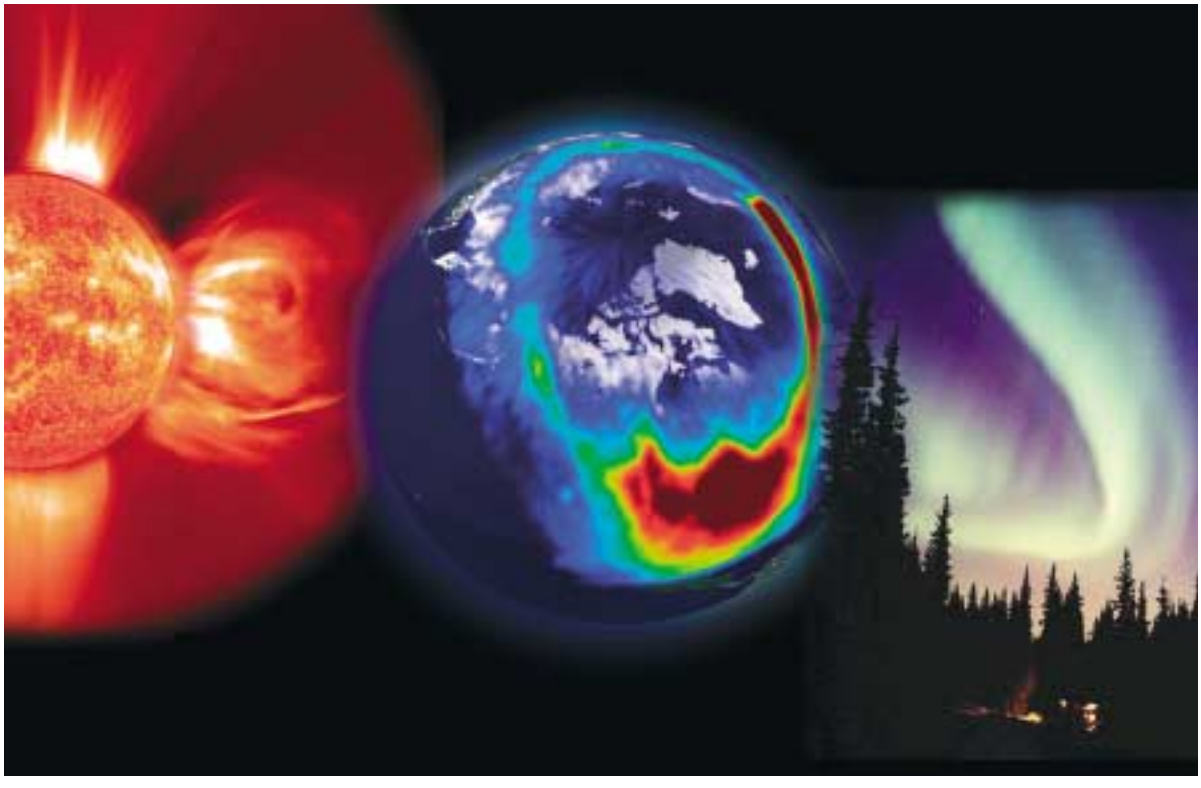
Several research projects completed in co-operation with local industrial enterprises yielded pro gradu and licentiate theses.

## Medical Physics Group

*Sauli Savolainen*

The main research areas were boron neutron capture therapy (BNCT) and medical imaging applications. The resources in the areas of BNCT dosimetry, dose planning, technological development, kinetic mathematical models for boron-10 and animal models have already been exploited. The international recommendations on BNCT dosimetry have not been available. Therefore, the research project of Code of Practice for BNCT was started in 1998 as a joint study within the EC research programme. The project consortium consists of twelve institutes from seven European countries. The Finnish institutes involved are the University of Helsinki, the Technical Research Centre of Finland and the Radiation and Nuclear Safety Authority of Finland (STUK). The main contributions of the Finnish consortium have been collected into five PhD theses and six Master's theses. One area of future research and development is a search for optimal blood-tumour $^{10}$B-concentration, and the methods to detect the boron distribution *in vivo*. The use of $^{1}$H magnetic resonance spectroscopy (MRS) in the quantification of the boron distribution is under investigation.

A part of the laboratory of medical physics is functioning within the Functional Brain Research Unit of the Helsinki Brain Research Center which has been granted a status of a Centre of Excellence by the Academy of Finland for the years 2002–2007. The most significant finding in the field of perfusion imaging methodology development was the assessment of determining one of the most fundamental indices describing tissue perfusion and cerebral blood volume, showing that the traditional methods fail in performing quantitative measurements and novel methodology is required.



Solar activity and its effects around the Earth, the so-called space weather, are a focal topic in space physics research at the Department of Physical Sciences. (Pictures ESA)

In the area of medical imaging applications, the utilization of multimodal imaging techniques has also had a powerful impact. Combined MR imaging, transcranial magnetic stimulation (TMS) and EEG 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. The main goal is to understand the mechanisms underlying the TMS-evoked neuronal excitation and, ultimately, to develop a clinical tool for mapping the physiological condition and connections of different cortical areas.

Researchers attended several international conferences during 2002 including the annual Scientific Meeting of the International Society of Magnetic Resonance in Medicine (ISMRM) in Glasgow, the XII World Congress of the International Society for Brain Electromagnetic Topography in Naples, the European Association of Nuclear Medicine Congress (EANM) in Vienna and the International Congress on Neutron Capture Therapy in Essen.

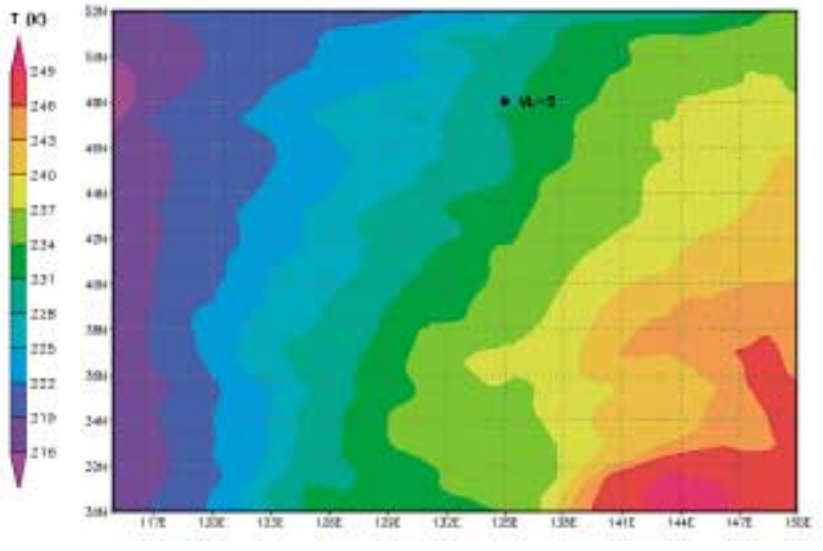
The Laboratory of Medical Physics has been financed by the Academy of Finland and the State Subsidy for University Hospitals which are gratefully acknowledged.

## Space Research Unit

www.physics.helsinki.fi/~tfo_www/research/space/

*Hannu Koskinen*

In space research a large variety of physics expertise is useful and, indeed, necessary. This is characteristic of the development process of the structure of space research at the Department of Physical Sciences has developed during the last few years. At present the topics studied include space plasma physics, cosmology, high-energy astrophysics, planetary meteorology and geophysical studies of past meteorite impacts. These fields have developed rather independently in different research groups as a result of the groups' 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. This type of distributed research activity requires co-ordination, for which the Space Research Unit was established in August, 2001. The Unit is responsible for the external relationships and reporting of the research activities but the personnel resources and teaching are distributed to the various Divisions according to their respective expertise and responsibilities.




Temperature map in Mars near the landing site of Viking Lander 2 after sunrise. The temperature at 1.5 m height is simulated using the Mars Limited Area Model developed at the Division of Atmospheric Sciences. Local time in the west (left) is 07.30 and in the east (right) 10.30. Adjacent isocontours differ by 3 degrees Kelvin. Note the 30 degree temperature difference in three hours. (Figure by Janne Kauhanen.)

In 2002 the total volume of space research at the Department of Physical Sciences reached its all-time highest, with 20 person years and an expenditure of about 1.1 M€, of which around 70 % came from external sources. The activity growth from the previous year was 25%. The main reason for the growth was the Antares programme of the Academy of Finland and the National Technology Agency, Tekes, which was running its first full year in 2002. The Department of Physical Sciences has a leading role in three of the nation-wide 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 have significant participation in the high-energy astrophysics consortium led by the Department of Astronomy.

Space research is always conducted in wide national and international co-operation. In space physics the collaboration with the Finnish Meteorological Institute includes the jointly funded professorship initiated in 1997. The co-operation was reaffirmed in 2001, and in 2002 Hannu Koskinen was selected to the permanent 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 involves 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 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 international space organizations in 2002. Prof. Koskinen was nominated to the Finnish Delegation of the ESA Science Programme Committee in 2002. Furthermore, he represents the Academy of Finland in the EISCAT Council, is a member of the European Space Science Committee of the European Science Foundation and the chairman of the Finnish National Committee of COSPAR, which implies that he represents Finland in the COSPAR Council as well. Prof. Enqvist serves as a member of the Fundamental Physics Advisory Group of ESA.

The Department of Physical Sciences will continue to develop space research activities at the Kumpula campus in wide national co-operation. The strong foundations in theoretical and experimental physics provide a solid background for continued success. After the move of the Finnish Meteorological Institute to Kumpula in 2005, the campus will become the strongest space research environment in Finland.

## Theoretical Nuclear Physics Group

*Dan Olof Riska*

A large $N_C$ analysis of the modern realistic phenomenological nucleon-nucleon interaction models revealed that the magnitude of their components is consistent with the large $N_C$ scaling of their operator structure (see publications of the group in the appendix).

The spectrum of systems formed of four constituent quarks and one antiquark was calculated with a flavor-spin dependent hyperfine interaction, which organizes the spectrum of 3-quark systems in agreement with the empirical baryon spectrum. These states model the mesonic cloud components of the baryon resonances. The spectrum of the 5-quark systems was shown to be numerically dense and to begin in the region of the low lying positive resonances, which consequently are expected to have strong 5-quark admixtures.

A study of pion rescattering in two-pion decay of heavy quarkonia was carried out. The structure of the empirical pion spectra was shown to be very sensitive to the presence of pion rescattering.

The coupling of $\eta$ mesons to quarks and baryons was determined by a quark model calculation of neutral pion decay of the charmed strange vector meson $D_s^*$.

A comprehensive study of all the observable electromagnetic decay rates of heavy quarkonia and heavy light mesons was carried out.

## Experimental Nuclear Physics Group

*Kari Eskola*

The long term collaboration with the RITU group led by Professor Matti Leino has been continued at the Accelerator Laboratory of the University of Jyväskylä. The experimental studies have been focused on nuclei with $100 < Z < 103$ and $N \sim 150$. The recoil tagging method has been employed at RITU with both gamma-ray arrays and elec-

tron spectrometers. An example of the latter is the measurement of conversion electron cascades resulting from the $^{48}Ca(^{208}Pb,2n)^{254}No$ reaction by the SACRED electron spectrometer. Decay properties of the nuclides $^{250}Fm$ and $^{254}No$ and their known, but inadequately characterized, long-lived isomeric states have been further investigated. Shape coexistence and exotic nuclei in neutron deficient shells in the lead region are also studied.

Neutron deficient nuclei close to the double magic nucleus $^{100}Sn$ are studied through in beam measurements both with the GASP and Euroball detector set-ups in co-operation with research groups from Sweden.

## Accelerator Laboratory Division

www.acclab.helsinki.fi

*Eero Rauhala*

The scientific activities during the past year have been focused on experimental and computational materials physics using ion beam techniques and first principles simulation methods, plasma accelerator techniques as well as laser, molecular and applied nuclear physics studies. The accelerator and computational teams working closely have together strived towards the understanding of basic ion-solid interactions, processing and applications of semiconductor and optical technology materials. The long-standing goal in the laboratory has been to develop new processes and materials using the potentials of ion beam methods. Thorough efforts have also been concentrated on the development of ion beam analysis methods, techniques and equipment.

The main endeavor in the laboratory was the installing, implementing and testing of the new 500 kV implanter. The apparatus was shipped in March and the set up by the technicians of the manufacturer, High Voltage Engineering, was completed in June. For radiation protection and air conditioning, an impressive brick and concrete construction was erected to house the accelerator in target hall II. The equipment is capable of producing a stable ion beam of up to tens of microamps from almost any elemental matter. An implantation beamline was procured originally and another beamline, intended for low-energy all-round ion beam analysis, modification and basic research purposes was built by the technical personnel of the laboratory. Two more beamlines are on the drawing board. Test runs utilizing both of the present beamlines and dose and energy calibrations were commenced in August. It turned out that all the specifications were clearly met. It was found, however, that the energy adjustment was too coarse especially for low-energy nuclear reaction measurements. To remedy the situation our technical per-

Photo: Seppo Andersson

sonnel devised computer control, which enables the energy to be controlled in steps of 30 eV, a value wholly adequate for the measurements needed. With this apparatus, the implantations are now possible in a much wider dose and energy range than before.

A major service was necessary also in the big tandem accelerator in autumn, with a 2.5 months halt in the research schedules. The charge conveyor belt was replaced – the first belt exchange since the implementation of the instrument in 1982 – and a new quadrupole lens system assembled and installed at the lower end of the accelerating tube. As a result, the beam stability, intensity and transmission through the accelerator were significantly improved.

The EU project concerned with fusion reactor wall materials was actively continued both with ion beam experiments and computational studies. The accelerator laboratory has more than 30 international co-operation partner laboratories worldwide. The main national collaboration of the accelerator team was continued with the Laboratories of Inorganic, Physical and Polymer Chemistry at the Department of Chemistry of the University of Helsinki, the Laboratories of Chemistry and Physics of the Helsinki Technical University and the Technical University of Tampere. In this collaboration the growth, structural and electro-optical properties of various materials were investigated by ion beam techniques. Materials such as metal oxide, sulfide, silicate and nitride thin films, formed by atomic layer deposition, were studied. Compound semiconductors were investigated with ion beams, e.g., concentrations of interstitial and substitutional nitrogen in $GaN_xAs_{1-x}$. Ion beam irradiation of polymer films and measurements of the resulting radioactivity were performed in an ongoing attempt to develop better fuel cell materials.

In 2002 the simulation team within the laboratory began to get results on the new research lines opened the year before. The studies of nanotubes determined the basic damage production mechanisms in both free and supported nanotubes, and also suggested ways to use the tubes as a mask against irradiation and produce junctions between tubes. The studies of cluster deposition gave insight into how nanocluster deposition can be used to produce both nanocrystalline and epitaxial thin films.

We have also studied the growth of stepped surfaces by using semirealistic Kinetic Monte Carlo (KMC) simulations. The step-flow growth mode contains many of those aspects which are of interest in many real surface growth problems. Results can also be applied in descriptions of nonthermal growth such as encountered in ion beam assisted growth (IBAD) and growth promoted by low energy ion deposition (LEID).

Among its other activities, the diamond group continued its work on the biomedical applications of amorphous diamond. With their new, internationally accredited hip joint tester the group proved that in body conditions the wear resistance of amorphous diamond coated hip implants is far superior to that of commercially available ones. In the new tester diamond coated joints have withstood tests equivalent to 15 years of clinical use without a failure. The diamond group also developed a new group of materials, amorphous diamond–polymer hybrids. These materials are very hard but they have extraordinary hydrophobic and oleophobic properties.

In molecular physics the structure and properties of biodegradable and chiral polyesters, and polymers containing fluorine have been studied by quantum mechanics and force field methods in co-operation with the biophysics group of the University of Michigan. Ring motions of small ring molecules were studied in cooperation with a group in Texas, and *ab initio* studies of charged molecules (acetate complexes) have been commenced with a group in Hungary. A new version of the molecular force field program Molvib adapted to the scaling of *ab initio* force fields has been prepared.

The collaboration of the laser physics group with the Finnish Geodetic Institute has continued with frequency stability measurements of gravimeter lasers. Noise properties of lasers systems and nonlinear dynamics in optically injected semiconductor lasers and diode-pumped solid state lasers have been studied.

We have succeeded in maintaining the relatively high level of outside funding from the Academy, Tekes, EU and other sources abroad, private foundations and the industry. The national graduate school in materials physics has provided the funding for 5 PhD students in their studies, two of whom achieved their PhD degree. Numerous research projects and a substantial part of especially the younger scientists have received their funding from these external sources.

## High Energy Physics Division

www.physics.helsinki.fi/~www_sefo/sefo.html

### 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, and Higher Dimensional Theories.

The group studies the implications of the noncommutativity of space-time in quantum field theories, concerning both the mathematical construction of the noncommutative quantum and gauge theories, and principal physical aspects, like spin-statistics and CPT theorems, causality and unitarity (for details, see the list of publications of the Group).

Another main theme of the group is physics in extra dimensions. In particular, the modified Kaluza–Klein reduction in higher-dimensional theories with orbifold compactification is performed. We study the effects of modified Kaluza–Klein spectrum on the gauge coupling unification in a realistic 5-dimensional $N$=1 supersymmetric SU(5) model of the Grand Unification. The modified Kaluza–Klein reduction opens new implications of higher-dimensional theories in particle physics, astrophysics and cosmology and provides significant modifications of collider phenomenology of extra dimensions.

The formalism of brane-like states (ghost-matter mixing) has a great significance in the attempts to understand the non-perturbative physics of strings and branes. In this formalism the DBI D-brane effective action from sigma-model with the ghost-matter mixing has been derived. A crucial result concerns the properties of the worldsheet renormalization group in backgrounds with the ghost-matter mixing and Feigenbaum universality in strings. Another important research topic has been the analysis of the Ramond–Ramond fields on a non-commutative background. Introducing Ramond–Ramond fields to non-commutative space-time brings about several novelties - non-perturbative breaking of the $B$-field gauge symmetry, as well as the shift of the GSO parity of spin operators, with subsequent implications for spin-statistics properties of spin fields in non-commutative backgrounds. The reference details for the work papers can be found in the list of publications of the Group.

In hadron physics the focus has been on properties of the QCD perturbative expansion. In a study of the properties of Feynman diagrams we have shown that the parton distributions measured in Deep Inelastic Scattering (DIS) do not have the probabilistic interpretation that is commonly assumed. Rescattering of the struck quark in the target affects the DIS cross section and introduces dynamical phases via on-shell intermediate states. This in turn is required for the observed phenomena of diffraction and shadowing in DIS.

Standard perturbation theory is an expansion around an empty, "perturbative" vacuum. This works well in QED but fails in QCD, most likely because the true QCD vacuum contains a quark and gluon condensate. We are studying the properties of perturbative QCD expansions around free but non-empty vacua. Such expansions are formally equivalent to the standard one and coincide with it in the short distance (leading twist) limit. However, in low momentum transfers they exhibit quark and gluon condensate effects as well as a spontaneous breaking of chiral symmetry.

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 centres in USA and Japan.

Photo: Seppo Andersson

## Experimental High Energy Physics

*Risto Orava*

The experimental high energy physics of SEFO is based on contributions to some of the leading experiments at CERN in Switzerland and at Fermi National Accelerator Laboratory in the U.S. The Helsinki group contributes to these energy frontier experiments through participation in their design, instrumentation and physical analysis.

Education and training of students is carried out in the framework of the leading international accelerator laboratories combined with the domestic detector laboratory at Kumpula Campus. The R&D activities are carried out in close co-operation with the Helsinki Institute of Physics.

In 2002, the Helsinki group was invited to join a leading active experiment in high energy physics, the CDF experiment at the Tevatron collider. This is an important milestone both in the search for new physics and in the preparations for the challenge of the LHC collider under construction at CERN.

An increasing number of students are taking interest in the field, and in the beginning of 2003 a record number of 27 students registered to the first introductory graduate level course in high energy physics.

*Physics analysis of $e^+e^-$ collisions*

The data analysis carried out by the Helsinki group is based on the data collected by DELPHI at the record energies of 207 GeV and it probes still unexplored domains of masses for new physics, including the theoretically favoured region for the Higgs boson. The emphasis of the physics analysis since the final running year, 2001, has been to ensure that the data is reconstructed with the most optimal reconstruction algorithms and detector calibrations, especially to answer the question whether a light Higgs boson exists or not? In heavy flavour physics, the group is pursuing an inclusive measurement of the lepton momentum spectra in semileptonic B decays based on the large set of $Z^0$ decays. The group is actively studying QCD coherence phenomena and has, for example, demonstrated for the first time the existence of the dead cone effect for heavy quarks. The group has also looked for pair-produced charged Higgs bosons, predicted by several extensions of the Standard Model, in the LEP2 data. The group has been an active participant in studies of the Higgs sector with a high luminosity $e^+e^-$ linear collider (TESLA) and R. Orava continues to serve as a member of the TESLA Executive Committee.

*Forward physics at the energy frontier colliders*

The forward physics project aims at providing an extension to the CMS experiment at the LHC in order to facilitate novel searches for new particles such as the Higgs boson and important measurements of strong interaction effects at the highest available energies. The physics signatures covered by TOTEM are complementary to the base line CMS, and include leading protons, rapidity gaps and particle production beyond the acceptance limit of the base line detectors. In addition to the strong interaction processes such as elastic scattering, diffractive excitation and total cross-section measurement, these signatures will serve as important tools in the search for new physics.

A realistic design of the forward detector system has to address the challenges posed by the need to carry out measurements close to the beam. The detectors have to operate in an intense radiation environment, be movable during beam injection, not interfere with the accelerator operation and meet the constraints due to the installation and access scenarios anticipated for the baseline experiment. They will have to fit into the limited amount of space available for additional detectors inside the experimental cavern.

During the past two years, the Helsinki group has developed a basic detector concept that meets these challenges. A series of prototype structures of microstations has been constructed for testing the mechanical structure and vacuum compatibility. The design and construction of a fully functional prototype is in progress. This prototype, together with a silicon sensor and its read-out electronics, has to be validated in a test beam.

*CDF activity*

In January 2002, the Helsinki group joined the CDF collaboration at Fermilab. During the past year the group started to integrate into the environment of the CDF experiment and made its first contributions, through co-operation with the Pohjois-Savo Polytechnical Institute, regarding the trigger and slow control systems of the Run II phase of the experiment. As the current collider of the energy frontier, the Tevatron presents a research facility with a high discovery potential. Moreover, the participation in the CDF experiment prepares the Helsinki group for a realistic forward physics programme at the LHC. The experience gained in the Run II phase of the CDF experiment at Tevatron will be used for learning about the physical challenges of a hadron collider, especially in the forward region, by using real data of an active experiment, as the past experience of the group is mostly with $e^+e^-$ collisions at LEP.

## 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, which has been partly reorganized in the new departmental Space Research Unit. In particle physics the topics of study are particle cosmology, theory of hot quark-gluon plasma and the physics of hadrons.

In particle cosmology, we have studied various aspects of inflation and baryogenesis. We have proposed a new model of inflation in which the inflaton is in a completely hidden sector. In this scenario both baryonic and dark matter originate from the decay of a flat direction of the minimal supersymmetric standard model, which is shown to generate the desired adiabatic perturbation spectrum via the curvaton mechanism. String-inspired alternatives to inflation, such as the so called ekpyrotic universe and various other pre-big bang-scenarios have also been studied.

Baryogenesis through fragmentation of an Affleck-Dine condensate and the subsequent formation of Q-balls has been investigated numerically. We also produced a first major review on the topic to appear in Physics Reports.

We continued to participate in the Finnish Planck Surveyor Consortium and in the Planck CTP working group, which is trying to establish ways to estimate the temperature and polarization spectra of Cosmic Microwave Background radiation. The activity has centred on concrete issues in map making, such as modelling the instrument noise that would appear in the temperature maps as stripes. To remove these we have developed an improved destriping algorithm.

Within the theory of quark-gluon plasma significant progress has been made by the computation of the last calculable coefficient of the perturbative expansion of the free energy. This was made possible by extensive use of new techniques of symbolic computation, since a computation by hand is unthinkable. Beyond this coefficient only fully numerical methods apply. With this result also the computation of the quark number susceptibility was driven as far as possible.

In hadron physics the study of heavy-light quark systems using lattice methods has been continued by extending the earlier work to more realistic systems formed from one heavy quark and one light antiquark. This is now being further extended to cases involving one more heavy quark. At a more phenomenological level, charge symmetry breaking and pionic inelasticities are studied in few-nucleon systems. Investigation of the meson-nucleon system has continued to link the fundamental QCD dynamics to experiment with effective field theory techniques.

Work on the canonical formulation of Yang-Mills theory has continued and a formulation involving only unconstrained fields in the case of SU(2) has been obtained. Extension to SU(3) is in progress.

The Division works in very 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. Internationally, contacts are particularly close with the Brookhaven National Laboratory, CERN, DESY, Nordita and Universities in Aachen, Bern, Bielefeld, Cambridge, Lausanne, Liverpool and Lund. The Division is also associated with two EU networks.

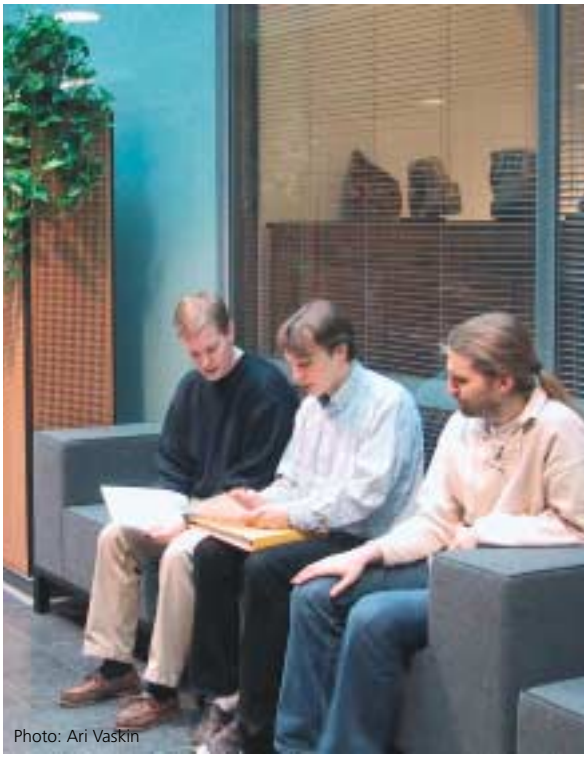


Photo: Ari Vaskin

## Division of X-ray Physics

www.physics.helsinki.fi/~xray_www/

*Seppo Manninen*

The first full calendar year in Physicum has passed productively. Experimental facilities operate at almost full strength now. The major new investment, a rotating anode x-ray set-up including a new small angle scattering unit and a scanning high resolution spectrometer, should be operating in the early spring of 2003. The personnel has increased being now about 30 and divided into research groups in hard and soft condensed matter, biophysics, medical physics and applied physics.

In addition to the use of the modern experimental facilities in the home laboratory, a substantial part of the experiments was carried out at large scale research centres abroad. Altogether 34 visits were made to ESRF, HASYLAB, ILL and SPring-8, in terms of working days this means 408 days. One should also notice that all experiments at these laboratories run 24 hours/day.

Russian scientists from the Institute of Crystallography in Moscow made several visits to use the four-circle diffractometer facility in the laboratory. The main domestic partners were the Helsinki University of Technology, the Finnish State Research Centre, the Institute of Biotechnology, the Helsinki University Central Hospital, the Department of Astronomy and the Department of Chemistry.

Timo Paakkari retired in May after working for more than 40 years in the department. At the farewell party many of his scientific co-authors during these years recalled the days when they were working together. He still shares an office in the laboratory for giving experienced advice gathered during those years.

Keijo Hämäläinen was appointed (1.9.2002) Professor of Experimental Solid State Physics, the position Timo Paakkari had held. Being somewhat below 40 years old he still has more than a quarter of a century to contribute to physics research and we all believe that the Division of X-ray Physics will benefit from those years.

The external funding, about 580 000 €, in 2002 was at the same level as in 2001. The main sources were the Academy of Finland and the ESRF. Additional special funding, related to the move into the new facilities at the Kumpula campus, was obtained. Space physics and small angle scattering were the main targets of instrumentation.

A record number of six MSc theses were accomplished in 2002. Five of those achieved a MSc degree. Kaija Jokela defended her PhD thesis successfully.

The Division of X-ray Physics organized a synchrotron radiation related summer school in June at the research station of University of Oulu. Altogether 33 participants (12 from our Division), including 2 foreign speakers, enjoyed three sunny days on the shore of lake Oulujärvi. The program consisted of invited lectures and contributions of the participating MSc and PhD students.

An evaluation of the safety risks in the laboratory was performed in 2002. This was particularly important because everyone is now working in a new environment. On the basis of the risk mapping a guide was written to be used by everyone working in the Division of X-ray Physics.

Photo: Seppo Andersson

## Division of Atmospheric Sciences

www.atm.helsinki.fi

*Markku Kulmala*

The Division of Atmospheric Sciences is a merger of the former Department of Meteorology and the Laboratory of Aerosol and Environmental Physics from Department of Physics. The chair of space physics also belongs to the Division. 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 45 scientists (including doctoral students) worked in the division in 2002. 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 (61°51' N, 24°17' E) and the SMEAR I station in Värriö (69°46' N, 29°35' E). 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.

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 innovations 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

Photo: Eero Roine

the atmospheric boundary layer. For example in Hyytiälä (SMEAR II station) ca 50 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 $CO_2$/aerosol interaction in the SMEAR stations, (vii) phase transitions in aerosols, (viii) UV-induced $NO_x$ emissions, (ix) novel instrumentation for laboratory and field studies to investigate the organic fraction of aerosol particles in situ: Organic TDMA, (x) development of basic nucleation theories based on molecular dynamics and Monte Carlo simulations as well as a density functional approach and classical thermodynamics, (xi) development of aerosol dynamic codes to investigate formation and growth of aerosol particles, especially organic aerosols.

The Division has direct working connections to more than 40 international laboratories and has participated in more than 20 EU projects. The Division has also direct connections to 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 University of Kuopio, the University of 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. In addition to that, the international postgraduate training programme of aerosol and environmental physics, which was started in the beginning of autumn semester in 1994, was continued during 2002.

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

## Division of Geophysics

geophysics.helsinki.fi/index.html

Activities of the Division of Geophysics embrace the physics of the hydrosphere and solid earth geophysics, both areas of broad scope. The former includes hydrology, physical oceanography and glaciology and the latter includes seismology, geodesy and geomagnetism. Research activities comprise snow and ice, polar oceanography, Baltic Sea, lakes, and solid earth.

Main topics have been lake climatology, lake optics, sea ice dynamics and morphology, snow conditions in Finland and Baltic Sea climatology. The work is partially basic research and partially applied research concerning the climate and environment. The main funding sources have been the Ministry of Education and the Academy of Finland.

### Geophysics of Water Mantle

*Matti Leppäranta*

Oceanography and Sea Ice

The theoretical investigations and the mathematical modelling of the dynamics of sea ice continued. This has been a large international project and all freezing seas have been studied, especially the Baltic Sea, the Sea of Okhotsk in a Finnish-Japanese collaboration (the University of Hokkaido) and the Northern Polar Sea in co-operation with researchers from Finland and the United States. There have been great achievements concerning the scaling of dynamics and the analysis of the frequency spectrum of the velocity of sea ice.

The emphasis in sea ice modelling was on modelling of the thickness distribution of the ice. As a part of the FIGARE project of the Academy of Finland, the Division of Geophysics developed a new generation ice model, which solves the thickness distribution for the numerous ice thickness categories of evolution. The model is linked up with the global sea model developed in the Max Planck Institute in Hamburg. Climatological simulations have been made with the model and they have been a basis for an estimation of the portion of both particularly thin new ice and banked ice in the ice balance of the whole Arctic Ocean.

A four-year long observation programme was concluded in Santalahti in the Hanko Peninsula region. The material collected consists of information on the development of the ice and snow conditions during the winters of 1999–2002, including the ice–air and ice–water interaction processes. The goal was to study the structure and properties of ice, as well as the thermal balance and the optical properties of ice and snow. The programme was executed as Finnish–Japanese collaboration, by the Division of Geophysics from the University of Helsinki and

the Institute of Low Temperature Science from the University of Hokkaido.

The spread of river water in winter conditions was studied at the Gulf of Bothnia in a project funded by the Academy of Finland. Also the structure and chemistry of sea ice was followed in experiments in Hailuoto in the reseach station of the Gulf of Bothnia. In addition, the Swedish ice-breaker Atle was used to collect samples from the western Gulf of Bothnia in co-operation with biologists from the Universities of Helsinki and Kiel.

An extensive study on the quality of water immediately south of Helsinki was completed; collaborators were the Finnish Environment Institute, the Uusimaa Regional Environment Centre and Helsinki Water. The central goal of the study was to define the behaviour of turbid waters, for example those of Vantaa River, in the coastal sea areas. The results of the research are illustrated in section Awards and Honours.

Hydrology and Optics of Natural Waters

With the help of new climate scenarios, preliminary model runs were performed concerning the Pääjärvi Lake in Lammi. As the climate warms up the ice coat period grows shorter, and models should be developed accordingly.

The optics of natural waters studies the behaviour of light in water. The optical research of the Division of Geophysics focuses on muddy and slightly muddy coast and lake waters. The most significant motivations for the research are the scarcity of field measurements in multicomponent waters (waters with a noticable amount of different opticly active materials) and the optical models functioning in them, as well as the high contents of both the dissolved organic matter and solid matter in these waters.

In 2002, the Finnish–Estonian optical collaboration project (SUVI) was pursued for the ninth year, and its third stage (2002–2003) was finished. In June, measurements were performed on Estonian lakes and on the Pohjanpitäjä Bay in front of Tammisaari, and in August on lakes in Southern Finland. An extensive measurement campaign was also conducted in the sea area before Tvärminne and Tammisaari, in co-operation with researchers from the Estonian Marine Institute and the Department of Limnology from the University of Uppsala. This campaign was a part of the "Influence of Freshwater on Coastal Oceanography in the Baltic Sea" project, which is funded by the Division of Environmental Research from the University of Helsinki.

Along with measurements, year 2002 was fairly active regarding interpretation of results and publishing activities. Antti Herlevi finished his doctoral thesis mainly based on the results of the SUVI project, see Highlights of Research.

Research of Snow and Ice

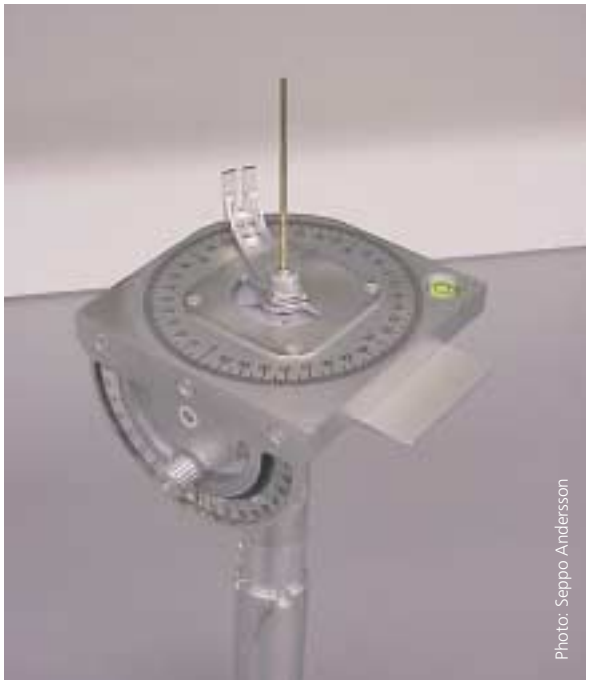
The graduate school of snow and ice was concluded officially at the end of 2002, but the research of the area continues in the Division of Geophysics for example by map-

Photo: Eija Kärkäs / FINNARP

ping and modelling the Finnish snow conditions. The use of the Swiss numerical SNOWPACK model for the Finnish snow cover was initiated in co-operation with the Swiss SLF Institute.

Optical studies of snow and ice have been performed in the Santala Bay north from Hanko Peninsula and in Kilpisjärvi. The studies in Santala are a part of the research project funded by the Walter and André de Nottbeck Foundation, which examines the effects of the optical properties of sea ice on the sub-ice light field and from there also on the population living in water and ice. In addition to the ice itself, also salt pockets affect the damping of light in sea ice. Therefore one purpose of the research has been to develop an optical model which would consider the affect of the salt pockets.

The studies at Kilpisjärvi were a part of a research project funded by the Magnus Ehrnrooth Foundation. In that project the purpose was to study the changes of the albedo (the reflection of radiation) of snow in the changes in the properties of snow and lake water. Especially during melting the albedo changes rapidly as the amount of liquid water increases.




A novel suncompass for orienting rock samples in the field. Oriented hand samples are needed in paleomagnetism to calculate the drift of continents in the geological past. The suncompass was constructed in the workshop of the Department of Physical Sciences by Pauli Engström according to conceptions of Matti Leino and Lauri Pesonen.

"The Snow Conditions in Antarctica" project receiving financing from the Academy of Finland for the years 2002–2005, so the study of the snow cover of Antarctica executed in the Division of Geophysics continues in close association with the University of Sherbrooke from Canada.

## Solid Earth Geophysics

*Lauri Pesonen*

The Group continued the construction of a new solid earth geophysics research and teaching laboratory in the basement of Physicum, which provided the laboratory premises. A hysteresis facility from Princeton Instruments Co and a susceptive-based Curie bridge from AGICO Co were installed into the laboratory. It is now possible to measure all geophysically relative properties of rocks, minerals and extraterrestrial materials in the laboratory. A new solar director was built in co-operation with the work shop of HIP, the Helsinki Institute of Physics, for future sampling. Measuring the magnetism of aerosol particles in collaboration with the aerosol laboratory of the Division of Atmospheric Sciences was a novel experimentation. Fabio Donadini continued the mapping of the strength of the Precambrian magnetic field, in international collaboration. During the year the plans to purchase a supraconductive magnetometer (SQUID) in the spring of 2004 were confirmed.

The Group of Solid Earth Geophysics participated in four international enterprises: the IGCP-440, the ESF-Impact, the ICDP and the GISP. Lauri Pesonen acted as the Finnish co-ordinator in the IGCP-440 and the ESF-Impact projects. The IGCP-440 was concerned with testing the existence of Precambrian supercontinents and is based on global paleomagnetic material. A large review article was written on the topic and several presentations were held. The ESF-Impact project was concerned with studying the ages of Finnish meteorite craters with the help of paleomagnetism and also with modelling the structures of the craters, basing all on geophysical materials. The work is financed by the Academy of Finland (the doctoral dissertation project of Maria Kuulusa and the pro gradu thesis of Johanna Salminen). The emphasis was particularly on the investigations of the double crater found in 2002 in Suvasvesi. The studies of petrophysical properties of meteorites were proceeded as an international collaboration. An extensive summary article was written on the investigations. The paleomagnetic studies of the Estonian Cambric-Silurian period were continued in co-operation with Jüri Plado from the University of Tarto.

## Development of new laboratory facilities for space research

Physicum offers new possibilities for scientific instrument development. Instruments to be flown in space must typically be manufactured and tested in especially clean environments. An example of this is the characterization of x-ray space detectors. For this purpose the Division of X-ray Physics has assembled a unique x-ray set-up which is capable of operating within soft x-ray region down to a few keV photon energies. The custom made vacuum chamber and the air-cooled x-ray tube are located within a clean room environment thus meeting the high level purity standards. During the summer of 2002 an extensive testing of an x-ray solar monitor (XSM) was performed in this new facility. The instrument was later integrated to the European Space Agency's SMART-1 spacecraft, which is waiting for its launch toward the Moon in 2003.

*J. Huovelin, L. Alha, H. Andersson, T. Andersson, R. Browning, D. Drummond, B. Foing, M. Grande, K. Hämäläinen, J. Laukkanen, V. Lämsä, K. Muinonen, M. Murray, S. Nenonen, A. Salminen, H. Sipilä, I. Taylor, O. Vilhu, N. Waltham and M. Lopez-Jorkama, The SMART-1 x-ray solar monitor (XSM): calibrations for D-CIXS and independent coronal science, Planetary and Space Science 50 (2002) 1345–1353*

## Adiabatic CMB perturbations in pre-Big-Bang string cosmology

The pre-Big-Bang model (PBB) is a string theoretical model in which the Big Bang is preceded by a universe which collapses after an infinite time. Observations imply adiabatic density fluctuations of the cosmic microwave background (CMB), which were thought not be properly explained by the PBB model: it seemed that the model produces only isocurvature fluctuations. We have however shown that if the PBB axion field (or one of the axions) decays into photons, it is possible to generate adiabatic density fluctuations in PBB cosmology which actually dominate over the isocurvature ones. Therefore the PBB model appears to be a good candidate for explaining the observed CMB data.

*K. Enqvist and M. S. Sloth, Adiabatic CMB perturbations in pre-Big-Bang string cosmology, Nucl Phys B626 (2002) 395–409*

Solar x-ray monitor to the ESA SMART-1 under tests in the new clean room laboratory at Physicum.

## Inherent and Apparent Optical Properties in Relation to Water Quality in Nordic Waters

The study of turbid and moderately turbid coastal and lake waters is the first comprehensive Finnish project focusing on the wavelength dependency of optical properties and their reciprocal relations, as well as on hyperspectral water quality models and the changes in the optical properties of Nordic waters. The results gave new information on the optics of boreal waters, about the relationships between inherent and apparent optical properties and wavelength dependencies of the scattering and backscattering of light. These are important for optical models and remote sensing of lakes and coastal waters. Also new knowledge was gained on some practical methods that can be used in monitoring water quality. During the years 1994–2001, hundreds of measurement series were available from approximately 40 targets, mainly from Finland and Estonia.

See figures in the chapter Awards and Honours.

*A. Herlevi, A study of scattering, backscattering and a hyperspectral reflectance model for boreal waters, Geophysica 38 (2002) 113–132*

*H. Arst, A. Erm, A. Reinart, L. Sipelgas and A. Herlevi, Calculating irradiance penetration into water bodies from the measured beam attenuation coefficient II: Application of the improved model to different types of lakes, Nordic Hydrology 33 (2002) 227–240*

*A. Herlevi, Inherent and apparent optical properties in relation to water quality in Nordic waters, Report Series in Geophysics No. 45, 2002, PhD thesis, ISSN 0355-8630, ISBN 952-10-0872-5 (pdf)*

## Possible doublet meteorite impact crater in Finland

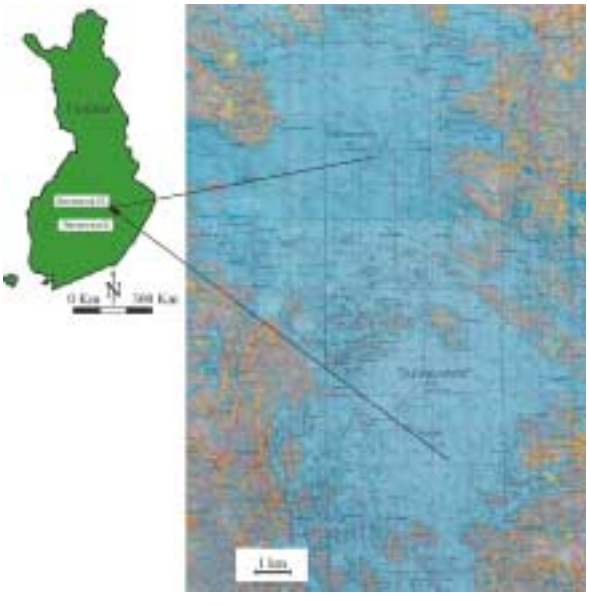
Two lakes in Eastern Finland, the Suvasvesi North and the Suvasvesi South, form a distinct pair. The Suvasvesi N structure has earlier been discovered to be formed by a meteorite impact, which has lead to a fascinating possibility that the two form a doublet crater. This year convincing new evidence was found, that the Suvasvesi S structure is also caused by meteorite impact. This makes it possible that the two lake structures are connected and form a doublet. The discovery is significant, since such doublet craters are extremely rare on planet Earth. Also the small diameters (4.5 km and 3 km) of the lakes and the fact that both are associated with peculiar geophysical characteristics make them scientifically very interesting and call for dating the impact events in near future. The field expedition to the Suvasvesi South structure in the past summer was done with the help of Barringer Fund, granted to the Finnish impact research team.

*S. Werner, J. Plado, L.J. Pesonen, P. Janle and S. Elo, A subsurface model of the Suvasvesi N impact structure, SE Finland, In: E. Petrovsky, A. Hirt, R. Scholger, L.J. Pesonen, C. Auborg (editors), Phys Chem Earth 27 (25–31) (2002) 1237–1245*

*A. Abels, J. Plado, L.J. Pesonen and M. Lehtinen, The Impact Cratering Record of Fennoscandia, In J. Plado and L.J. Pesonen (eds.), Impacts in Precambrian Shields, Springer Verlag 2002, pp. 1–58*

## Indirect evidence of organic nucleation mode particles over the boreal forest

Indirect evidence for nucleation mode particles (diameter 3-10 nm) over the boreal forest comprising primarily organic material is presented. During regular spring-time nucleation bursts over the boreal forest in Finland, nucleation mode aerosol was characterized using a mobility size spec-



The Suvasvesi North and the Suvasvesi South impact craters, forming a possible doublet in Finland

trometer (DMPS) and a Pulse Height Analyser Condensation Particle Counter (PHA-CPC) in parallel. It was found that the growth of the nucleation mode particles in the CPC chamber was significantly larger than that of ammonium sulphate and other known inorganic aerosol species given its measured mobility. Laboratory experiments on perceived end-products of VOC oxidation over the forest (e.g. *cis*-pinonic acid and pinic acid) confirm that in the butanol condensation chamber of the CPC, organic nucleation mode particles grow to greater sizes than ammonium sulphate particles of the same size. While it was found that the use of the PHA-CPC would not retrieve nucleation mode size spectra, it did provide the first, albeit indirect, evidence of organic aerosol mass dominating the nucleation mode aerosol composition over the boreal forest.

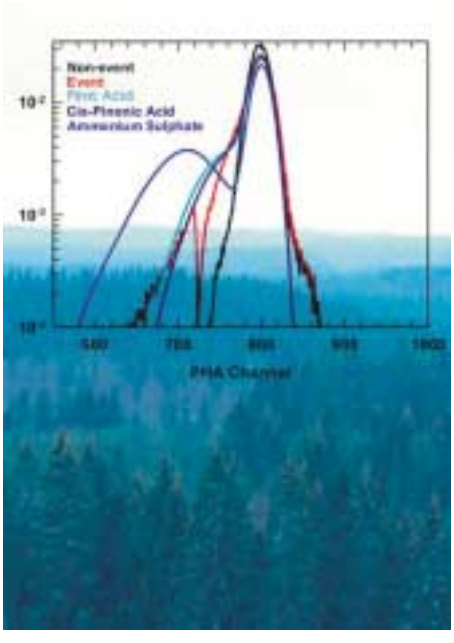
*C.D. O'Dowd, P.P. Aalto, K. Hämeri, M. Kulmala and T. Hoffmann, Atmospheric particles from organic vapours, Nature 416 (2002) 497-498*

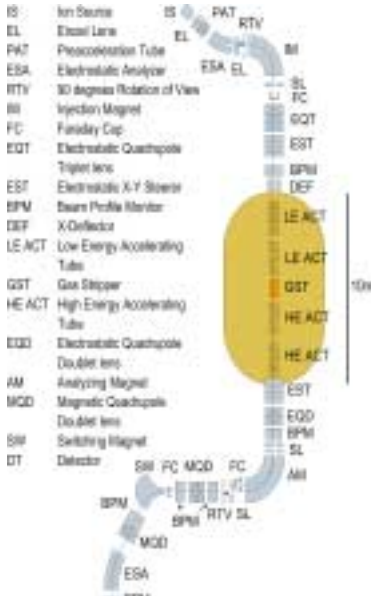
## Accelerator Mass Spectrometry for $^{14}C$ dating

The 5-MV tandem accelerator EGP-10-II of the Accelerator laboratory is adapted for Accelerator Mass Spectrometry (AMS). The system is in computer control. In the initial phase the AMS set-up is used for $^{14}C$ dating but the system can be adapted to measure $^{10}Be$, $^{26}Al$, $^{36}Cl$, $^{129}I$ and actinides. A precision of 2–3% has been achieved. Further optimization is expected to result in a precision below 1%. Present $^{14}C$ count rate is 30-40 counts per second from an oxalic acid standard. Total background including sample preparation is about 40,000 radiocarbon years.

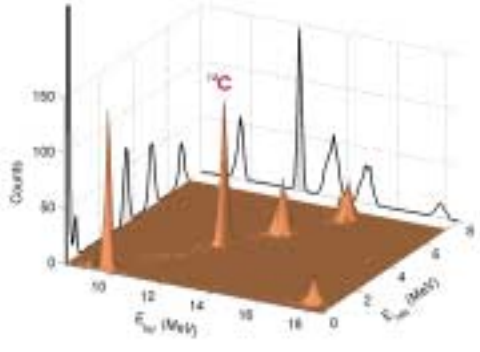
*P. Tikkanen, V. Palonen, H. Jungner and J. Keinonen, AMS facility at the University of Helsinki, Nuclear Instruments and Methods in Physics Research B, submitted for publication*

*V. Palonen, P. Tikkanen and J. Keinonen, Ion-optical modelling of the Helsinki AMS tandem, Nuclear Instruments and Methods in Physics Research B, submitted for publication*



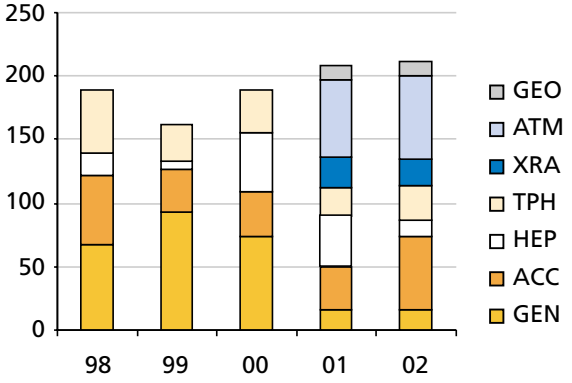




Schematic diagram of the tandem accelerator used as the AMS spectrometer.



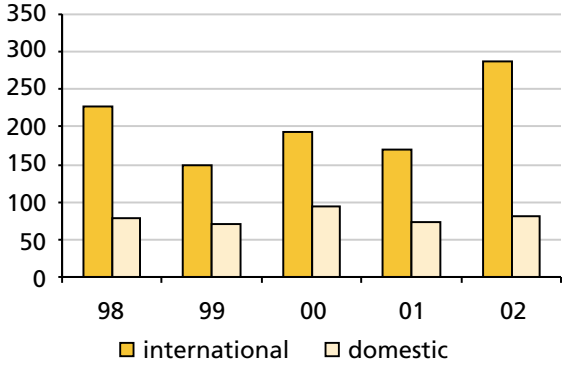

AMS spectrum measured for $^{14}C$ from a modern charcoal sample. In the sample the $^{14}C$ concentration is $10^{-10}$ atomic percent.

## PEER REVIEWED PUBLICATIONS




Number of peer reviewed publications in 1998–02 (Nota bene: Peer reviewed publications concerning geophysics and meteorology are included in the graph from the year 2001 when the Department of Physical Sciences covering also those branches of science was formed.)

## CONFERENCE CONTRIBUTIONS




Number of international and domestic conference contributions in 1998–02

## PUBLICATIONS

### Peer reviewed articles

In 2002 the personnel of the Physics Department published 211 articles in esteemed scientific journals with international peer reviewing systems, a few more than in 2001. A complete list of these publications is given in the Appendix.

There were 58 invited talks, 98 other oral presentations and 47 poster presentations in international conferences and 12 invited talks, 15 other oral presentations and 49 reports in domestic meetings. Detailed information about these can be found in the Helsinki University Knowledge Databases, http://www-db.helsinki.fi/muti/en/.

### Books

Lauri Pesonen, together with Jüri Plado, edited a book on the impact craters of Precambrian shields, published by the Springer Verlag publishing company. Lauri Pesonen also edited a special issue of the Physics & Chemistry of the Earth publications together with others.

Hannu Koskinen wrote with international colleagues a book on Auroral Plasma Physics published by Kluwer Academic Publishers.

Pekka Suortti contributed to the Encyclopedia of Physical Science and Technology by writing and article on X-ray, Synchrotron Radiation, and Neutron Diffraction. He was also one of the authors of an article called High-Energy X-ray Scattering at Third-Generation Synchrotron Radiation Sources which appeared in Third-Generation Hard X-ray Synchrotron Radiation Sources: Source Properties, Optics, and Experimental Techniques, given out by John Wiley & Sons, Inc.

Also this year, the personnel of the Department contributed in writing textbooks. O.J. Marttila wrote a chapter called Suureet ja yksiköt for Säteily ja ydinturvallisuus (Radiation and Nuclear Safety). Elektroniikan perusteet (Basic Electronics) by Juha Aaltonen, Seppo Kousa and Jyrki Stor-Pellinen appeared as a corrected third edition.

An issue called Vuorovaikutus (Interaction) appeared in a series of textbooks for the three highest years of secondary school, Lukion fysiikka, by S. Hassi, J. Hatakka, Heimo Saarikko and J. Valjakka. Full details of all these books are given in the Appendix.

## RESEARCH COLLABORATION

The Department of Physics has wide collaboration with many foreign universities and research centres. During the 3-year period 2000–02 peer reviewed articles involved collaboration with scientists from 218 European institutes, 78 institutes in North and 4 in Central and South America, 12 institutes in Asia, 1 in Israel, 1 in Africa and about 85 domestic ones. Scientists from the Department had also collaboration with four foreign and eight domestic companies, giving rise to publications during this 3-year period.

Twenty-six foreign scientific visitors worked in the Department for longer than one month (altogether 53 months), 32 visited for more than two weeks (altogether 20 months) and 91 persons paid a shorter visit. Of the departmental staff 23 persons visited foreign research centres for periods longer than one month (altogether 89 months, 3 people spent a whole year abroad) and 23 people for more than 2 weeks (altogether 15 months). Detailed information about the visitors can be found from the University Data Base at http://www-db.helsinki.fi/muti/.

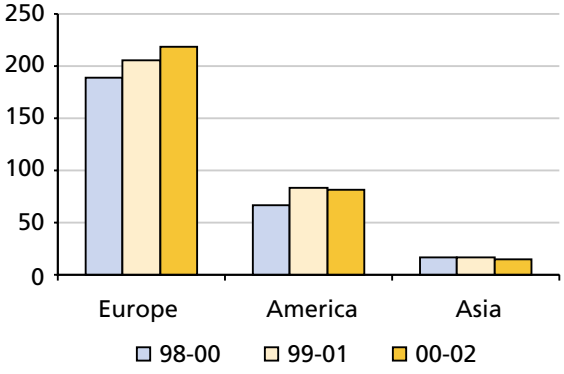
The research groups of the Department are in co-operation with tens of university departments in Finland (University of Helsinki, 45 laboratories and departments in 4 faculties, Helsinki University of Technology 14 laboratories, Technical Research Centre of Finland 7 departments, Universities of Jyväskylä, Kuopio, Oulu and Turku, 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 ORGANIZED

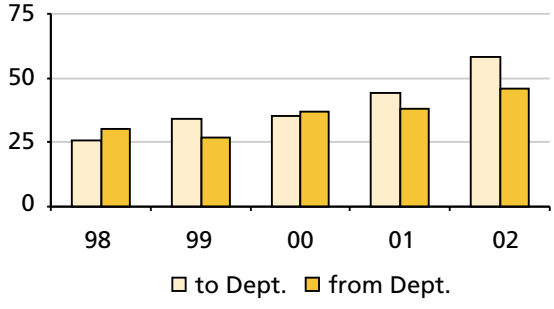
The Division of Atmospheric Sciences and the Nordic Research Council arranged a Workshop on implementation of dynamic aerosol models for large scale applications called “Dynamic aerosol modelling: from box models to 3D transport models”, 30th of January – 1st of February 2002 in Helsinki. The workshop aimed at identifying uncertainties and defining main priority research topics within aerosol process modelling with implications for the development of emission control strategies for particulate

### COLLABORATION INSTITUTES



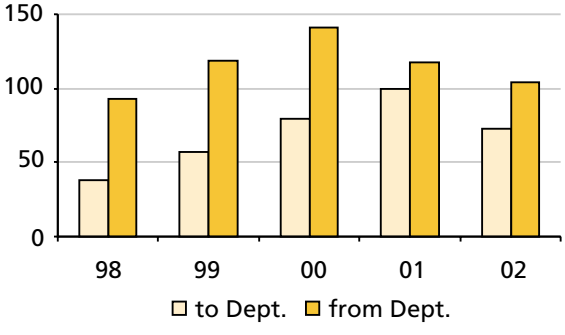

The numbers of collaboration laboratories in different continents in the 3-year periods 98–00, 99–01 and 00–02. Domestic and CERN collaboration with large research groups are excluded. Only those laboratories are included with which a peer reviewed article was published in a 3-year period.

### VISITING SCIENTISTS




Number of visiting scientists in 1998–02 who stayed more than two weeks

### TOTAL LENGTH OF VISITS (months)



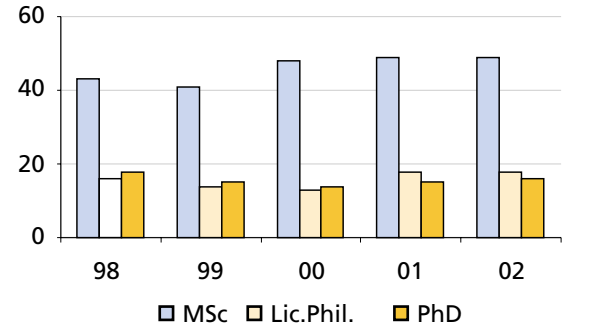

Cumulative duration of visits (> 2 weeks) in months in 1998–02

matter. It hosted members of the scientific community studying aerosol dynamic processes and scientists developing those in three dimensional transport models.

Other meetings arranged by the Division of Atmospheric Sciences were the 1st year meeting NORFRETETE 24.–27.11. at Hyytiälä Forest Research Station, the FIGARE 1999-2002 Finnish Global Change Research Programme, Closing conference 9.–10.12. in Hanasaari, the Swedish-Finnish Cultural Centre, Espoo, the NorFA Network for Atmospheric Aerosol Dynamics 7.–11.8. in Preila, Lithuania, Summer course 2002 with Finnish, Swedish, Lithuanian and Italian participants, the RUPIOH workshop, Univ. Helsinki, Physicum 2.–3.9. with 16 participants, out of whom 12 foreigners from 4 countries. Also the Nordic Centre of Excellence NCOE held its meeting in Physicum 24.–25.9. There were 36 participants from Finland and seven other countries.

In January hydrologists held a meeting in Physicum with the theme Challenges of hydrology in the international field. The seminar was aimed at experts in the field but for all it was a window into international views of hydrology with distinguished speakers from the Ministry of Agriculture and Forestry and the Finnish Environment Institute. The seminar and the exhibition were open to the general public. Professor Timo Huttula from the Division of Geophysics hosted the seminar.

**DEGREES**




**ECTS CREDITS**

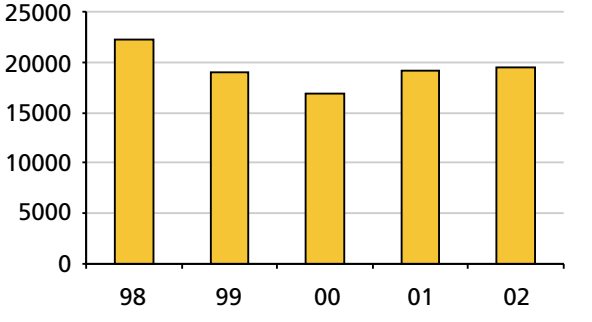



Photo: Seppo Andersson

# 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 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 Consistorium Major was 160. There were 436 applicants of whom 150 have started their studies. Ten of those entered the physics teacher line. The entrance examination was organized together with the universities of Jyväskylä, Oulu and Turku.

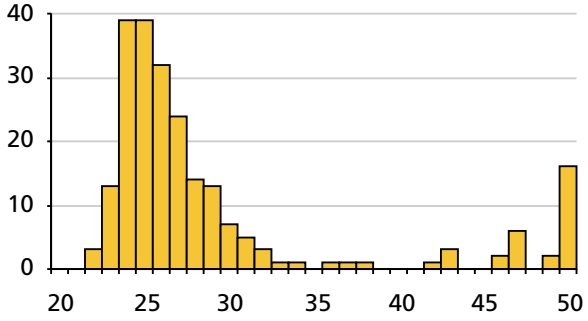
The number of ECTS (European Credit Transfer System) credits taken in the Department was 19,422 in 2002, which was 10.9% of all those taken in the Faculty of Science. (The study week concept, commonly used in Finland, is 1.5 ECTS credits.)

In 2002 49 students took their MSc degree in the Department. A list of the MSc theses is given in the Appendix. For the 5-year period 1998–02 the median age of those finishing their Master's degree was 26.1 years, about one year less than the median, 27.3 years, for the 5-year period 1993–97.

The proportion of women of those graduating from the Physics Department in the 5-year period 1998–2002, with figures for comparison for the 5-year period 1997–2001 in parentheses, were: PhD 23% (24 %) and MSc 29% (27 %).

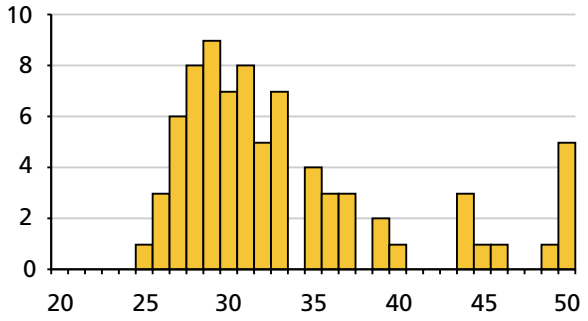
The similar proportion of women taking their PhD degree in the Department to the one taking their MSc degree shows that physics research in the Department has to a great extent fulfilled the aim of equality for researcher education.

AGE AT COMPLETING MSc DEGREE




Age distribution of students taking their MSc degrees in 1998–02

AGE AT COMPLETING PhD DEGREE



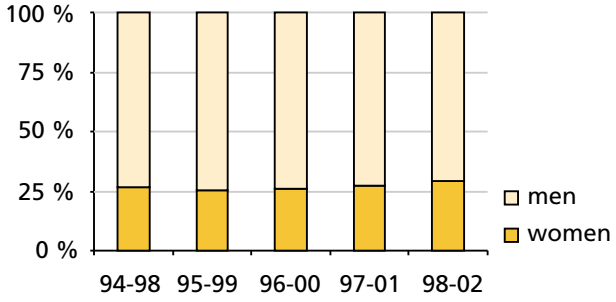

Age distribution of PhD graduates for 1998–02

### Summer schools and field courses

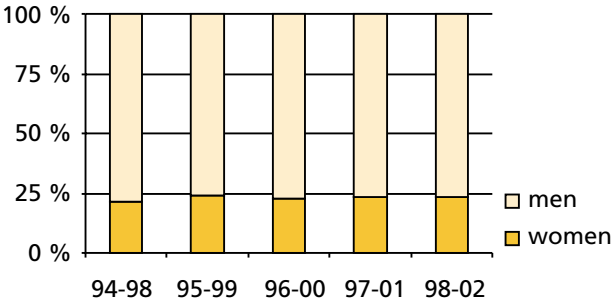
The summer school for the research-oriented physics students was organized during the first week of September. The school was held at the Lammi Biological Station about 130 km north of Helsinki. This year the topic of the school was "Experimental High Energy Physics". The aim was to give the students a broad introduction to the field of experimental high energy physics, covering aspects from the Standard Model, the current best knowledge of the interaction of elementary particles, to particle detectors and their readout.

The lecture program consisted of three lecture series in the mornings by the main lecturers: PhD Albert de Roeck (CERN) on "Particle Physics at Future Colliders", Doc. Katri Huitu (Helsinki Institute of Physics) on "Standard Model and Supersymmetry" and Prof. Valery Khoze (University of Durham) on "Strong Interaction". Lectures related to experimental issues were given in the afternoons by Prof. Risto Orava, PhD Kenneth Österberg (both from the Department of Physical Sciences, University of Helsinki), PhD Stefan Tapprogge and Lab.eng. Rau-

PROPORTION OF WOMEN TAKING MSc DEGREES




PROPORTION OF WOMEN TAKING PhD DEGREES




no Lauhakangas (both from Helsinki Institute of Physics). In the evening, there were short seminars on topical subjects like neutrino physics, extra dimensions and cosmology. Discussion sessions were also part of the program.

The scenic nature at Lammi helped to achieve a relaxed atmosphere to study physics and provided an excellent opportunity to enjoy many outdoor recreation activities during free time. There was also organized social program in the evenings which helped to increase the interaction between lecturers and the 25 students attending. The school was organized by PhD Kenneth Österberg with the help of Doc. Katri Huitu, Prof. Risto Orava and MSc (eng.) student Tuula Mäki.

A field course on hydrology and meteorology was held in the University's Forestry Field Station in Hyytiälä, Juupajoki, on 23.–27.9. The purpose of the course was to acquaint students with hydrological and meteorological measurements in forest, swamp and lake environments. The course was executed as a collaboration between the Divisions of Geophysics and Atmospheric Sciences, and the Department of Forest Ecology. The course was attended by 14 students.

The emphasis of the course was in measurement methodology and data processing. The course started with introductory lectures in Kumpula on the 9th of September. In Hyytiälä the students made measurements in small groups and worked the results into exercises. Afterwards there was also a seminar, where the students got to present the results of their work. The seminar was held in Kumpula in November.

There were several teachers on the course, from all the participating quarters. From the Division of Geophysics the teachers were Professor Timo Huttula and MSc Kai Rasmus. The teachers from the Division of Atmospheric Sciences were Professor Timo Vesala, MSc Sanna Sevanto and Docent Üllar Rannik. From the Forest Ecology we had the pleasure to hear Professor Pertti Hari, Hannu Ilvesniemi, Martti Perämäki and Docents Jukka Laine and Eero Nikinmaa. Also Tapani Sallantaus from the Pirkanmaa Regional Environment Centre attended as a teacher.

## Evaluation of student guidance

The Department of Physics was invited by the Finnish Higher Education Evaluation Council to participate, together with two other Finnish educational institutions, in the pilot project "Evaluation of student guidance in higher education". The evaluation consisted of an extensive self evaluation, followed by external audit. The conclusion confirmed by an independent assessment of students was that student guidance in the Department was in general good. Especially tuition of the first year students, as well as the research student program, the teacher training program and the international student exchange program received praise. However, different aspects of the student guidance practices will be developed in the future, in cooperation with student (association) representatives. In the new premises in the Kumpula campus closer co-operation with other departments is foreseen.

## 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 www-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 2002 University lecturer Kari Rummukainen was chosen teacher of the year. Professors Seppo Manninen and Timo Huttula obtained a diploma of honour. Student Klaus Larjo was chosen as the teaching assistant of the year.

## 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 institutions around Europe, and also a multitude of courses in English and international study programmes. As a result of these efforts, after a period of rapid increase the number of the Department's students leaving to pursue foreign studies for a semester or two levelled out at about ten annually.

The graph presents the development of the outgoing students' number. In the academic year 2001–02, perhaps partly due to the Department's moving to Kumpula in the previous spring, the number of departing students dropped significantly for the first time during several years. On the other hand, this followed the general trend in the whole university: after a rapid expansion of the exchange programmes, year 2001 has seen an overall decline in the number of departing students. However, in 2002–03 the number is back to ten. Also a shift, perhaps temporary, is visible in the desired destinations: after strong interest in central Europe within the Socrates scheme, now interest is higher in Nordic countries and in countries outside Europe. Supported by our Nordplus network many students take advantage of specialized centres, such as UNIS in Spitsbergen on geophysics, meteorology and space physics.

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 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 after their degree in the home university to pursue graduate research here.

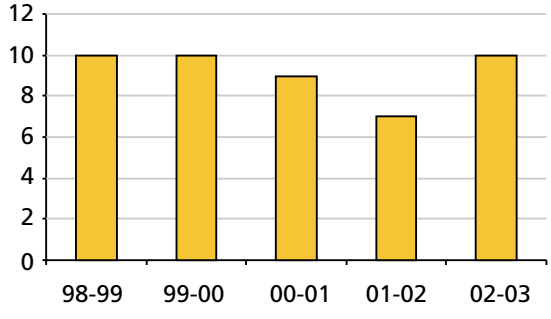
The Department offers a wide selection of teaching in English, of which most popular among foreigners have been various theoretical and environmental physics courses. In fact, most advanced courses in the Department can be taken in English when necessary. A total of over a 1200 study weeks (about 2500 ECTS credits) were obtained from courses given in English during 2002.

Since the spring of 1997 the Department has published its biennial ECTS Guide Book to accommodate fully the studies in physics as part of the common European Credit Transfer System. In addition, the book gives information about the contents and lecturing languages of the courses provided by the Department for European student exchange coordinators and potential students. It was well received by European student exchange coordinators and has certainly had an impact on the increased international interest in studies in our Department. This guide is also available on the web.

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 intensive courses like the Nordita Master Classes are regularly attended by some bright students of the department. Further, research groups may send advanced or graduate students abroad for short term research or conference trips.

Teacher exchange is another important part of the University's international pursuits. In 2002 one teacher from the Department gave an intensive advance course abroad under the auspices of the Erasmus/Socrates programme, while two exchange teachers lectured here. Also foreign researchers working at the Department or HIP gave short courses on special topics.

NUMBER OF STUDENTS STUDYING ABROAD




The number of students from the Department of Physical Sciences pursuing foreign studies for an academic year

## POST-GRADUATE EDUCATION

The Department of Physics is responsible for post-graduate training in physics, theoretical physics, particle physics and in physics teacher training, jointly with the Department of Teacher 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 the Department of Physics is in the top rank in Finland. The collaboration in post-graduate education with the Helsinki Institute of Physics (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 2002 16 post-graduate students took the degree of Doctor of Philosophy. Lists of the students who completed their Lic.Phil. and PhD theses in 2002 in the Department are given in the Appendix.

In the period 1998–02 the median of the age distribution of the graduating doctors in the Department was 31.1 years, smaller than the median 32.2 years in the period 1993–97. The effort to shorten the time needed to accomplish a doctor's degree by increasing monitoring of student progress will still continue.

In order to support and promote doctoral education the new "research education program" has been continued in the Department. A maximum of 20 undergraduate students with a doctoral perspective are chosen annually. 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 (eight persons), Particle and nuclear physics GS (four persons), Mathematics, physics and chemistry teachers GS (two persons), and Graduate School in Astronomy and Space Physics (one person).

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

Photo: Seppo Andersson

## 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.

The extended degree programme in adult education has continued in 2002. The supplementary-education programmes in didactical physics, DFCL, successfully completed by more than 250 physics teachers, has formed an important part of the national development effort to advance the Finnish awareness of mathematical and natural sciences in 2002. According to the responses of the participants, the new practices of modern processual teaching and perceptional experimentality have become everyday practice in many of their schools. Several of the study groups continue their activities as local centres of development. About 100 participants decided to continue their studies and research in didactical physics for a degree higher than BSc, and by now more than half of them have gained the Master of Science degree or laudatur as a minor in physics. The e-mail list of the DFCL programme is continued as a free-form network seminar to support these studies. More detailed information can be found in the URL http://didactical.physics.helsinki.fi/dfcl/.

During several decades the Department has arranged a week long 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 2002, geophysics was the theme of the course which was attended by 49 teachers. Twenty four of the participants were women and 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.**

## EXPERT SERVICES

The Department's researchers had leading positions in 80 international scientific organizations and in 34 domestic ones. These can be found in the Helsinki University Data Base at http://www-db.helsinki.fi/muti/.

The Department's researchers had 21 positions on the editorial boards of foreign scientific journals and four on the boards of domestic scientific journals. The researchers of our Department had altogether 84 refereeing positions in international scientific journals and one in a domestic journal. Two scientists had the position of editor-in-chief of an international science journal and one of a domestic journal.

Ten persons from our staff functioned as experts in 17 domestic boards, committees and other public bodies outside the University and in nine international ones. Eight of our staff had leading positions in 16 organizations, mainly domestic but also international.

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/.

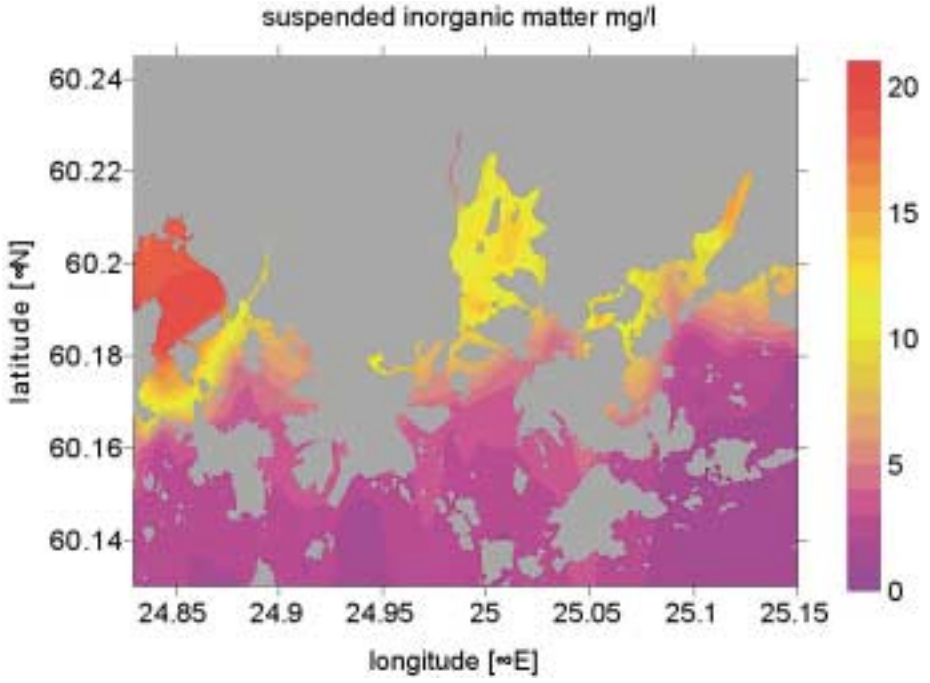
## AWARDS AND HONOURS

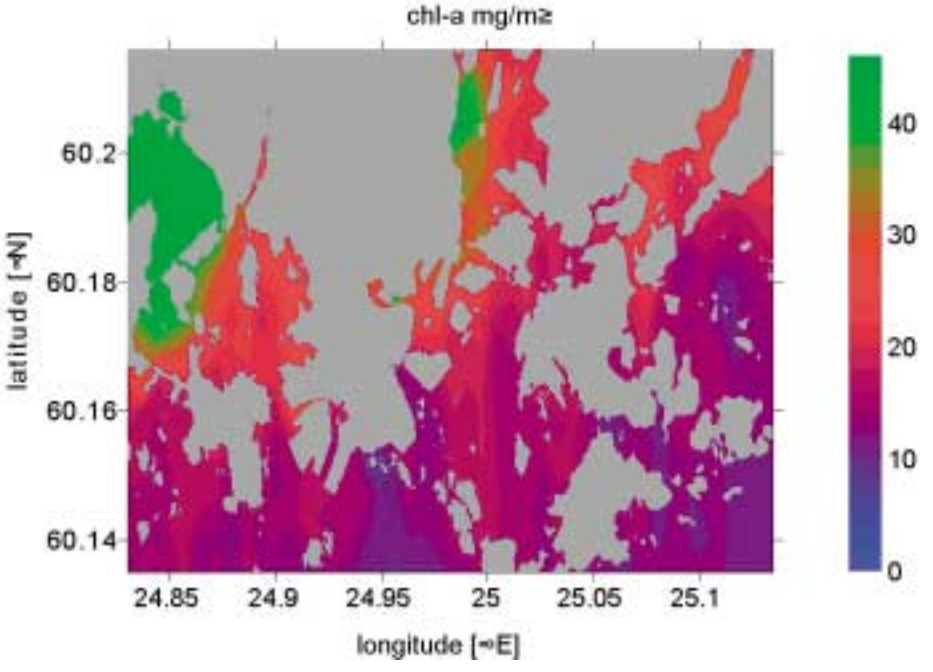
During its anniversary celebrations on the 29th of April, the Finnish Academy of Sciences and Letters – Societas Scientiarum Fennica awarded Professor Paul Hoyer 17.500 € for his significant research accomplishments in the field of particle physics. Prof. Hoyer worked from 1994 to the summer 2002 in Copenhagen as the Head of the Nordic Institute for Theoretical Physics.

The Finnish Academy of Science and Letters presented Professor Keijo Hämäläinen with the prize from the Viljo, Yrjö and Kalle Väisälä Fund. The prize has been founded in 2000 and is awarded yearly to one or more deserving researches leading an active career in the Fund's fields. The prizes of 15.000 € were festively presented in the House of the Estates on the 9th of December, this year the Board of the Academy had decided to give them to two professors. Professor Keijo Hämäläinen, held a presentation on "The hundred years of x rays".

The doctoral students Maria Kuulusa and Fabio Donadini were awarded the Barringer Family Fund scholarship of 4000 $ for the investigations of the Suvasvesi meteorite crater. Professor Lauri J. Pesonen was nominated as a member of the Finnish Academy of Science and Letters in April of 2002.

The business idea with which Antti Lindfors and Kai Rasmus from the Division of Geophysics won the first round in the national Venture Cup business competition was based on a new water quality measurement system. The new method allows the user to obtain 1000 times more accurate surface maps of water quality than has been possible with the existing systems. The high-resolution information can be used for e.g. environmental legislation purposes, monitoring work and remote sensing tasks.




Concentration maps of suspended inorganic matter and chlorophyll-α in Helsinki coastal waters during September 2002.

## VISITS

The Helsinki University Alumni Association made an official visit to the Physicum in April 2002, hosted by Juhani Keinonen. On the 17th of May the Rector of the University of Latvia was received by Professor Keinonen.

The veterans of the Union of Teachers of Mathematical Subjects (MAOL) visited the Physicum on the 14th of October and were received by our Public Relations assistant.

## INNOVATION SEMINAR

An innovation seminar was held in Physicum on the 21st of January. The topic was the innovation issues on Kumpula Campus. Such issues are, among other things, immaterial rights, financing issues and the commercialization of inventions. The seminar was opened by Professor Juhani Keinonen. The Executive Manager Kari Sipilä brought greetings from the Innofin and introduced Jari Rantala, the new Innovation Manager of the Campus. Research Manager Heikki Mäkipää held a presentation on the relationship of the University to inventions, and Professor Markku Räsänen talked about the development of an idea into a finished product.

## CHILDREN'S TECHNOLOGY CAMP

The children's technology camp took place in June in Physicum for the second time and was organized by the Industrial Information Agency owned by the Confederation of Finnish Industries and Employers. There were sixteen participants, who were 8–13 years old.

As the name of the camp indicates the programme focused on technology, even though pure science played its part, too. One of the broad themes of the camp was the relation of science and technology. The topics were handled mostly by the children themselves: they built simple devices, did short scientific research projects and experiments and reflected on the meaning of technology in everyday life.

Each day of the week had its own theme. On Monday it was scientific research and technological development framed by mechanics, on Tuesday the subject was electricity and on Wednesday materials research. On Thursday there was an excursion to the Vaisala company, and on Friday the theme was balance and creative problem solving. The climax of the camp was a tower building contest: the goal was to build as high a tower as possible using only newspapers as material. The week ended with an event, also attended by the children's families, where the participants' results were presented.

The practical arrangements in Physicum went smoothly as both camp leaders, undergraduates of the Department, were familiar with the venue. Furthermore one of them, Hannu Turunen, also worked in Physicum at the Department of Physical Sciences at that time. The attendants were very helpful and also the rest of the personnel was intrigued by the camp and the young inventors.

Again Physicum turned out to be an inspiring and interesting environment for the technology camp. The children enjoyed their stay in the modern and peaceful premises, and the only complaints concerned the free-time surroundings – there are sadly few green spaces nearby Physicum. Also the parents of the participants commended the place: they were pleased that the children could "get to university already so young". All in all the camp was a success, and many inquiries have already been made regarding the next camp. After these two experiences Physicum seemed to be an excellent location for a technology camp, where children can get a little contact with the world of science and of the University.

# *Supporting Activities*

## ADMINISTRATION

### 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 Board and the members of the Departmental Board were (with vice members in parentheses):

Prof. Masud Chaichian (Prof. Keijo Kajantie)
Prof. Juhani Keinonen (Prof. Risto Orava)
Prof. Markku Kulmala (Prof. Heimo Saarikko)
Prof. Matti Leppäranta (Prof. Hannu Savijärvi)

Doc. Hannu Kurki-Suonio (Dr. Hanna Vehkamäki)
Doc. Seppo Manninen (Doc. Merja Blomberg)
Doc. Niklas Meinander (MSc Timo Sajavaara) till 22.4.
from 22.4. MSc Timo Sajavaara (Doc. Tommy Ahlgren)
PhD Kimmo Ruosteenoja (MSc Kai Rasmus) till 22.4.
from 22.4. MSc Kai Rasmus (MSc Sami Niemelä)

Student Emilia Koivisto (Student Maaria Tervo)
Student Liisa Peltonen (Student Noora Korhonen)
Student Saija Vuorialho (Student Anne-Mari Vitikainen)
Student Anna Ruhala (Student Tuomas Lappi)

Lic. Phil. Tytti Varmavuo-Häikiö, Helsinki Polytechnic
Director, Prof. Mikko Alestalo, Finnish Meteorological Institute

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

Photo: Seppo Andersson

### Other administrative posts

#### Administrative posts at university and faculty level

Professor Juhani Keinonen was a member of the Consistorium Major, and senior assistant, Docent Björn Fant was also a member of the Consistorium Major in the quota for non-professorial representatives of teaching and research. Professor Heimo Saarikko was the representative of the Faculty of Science in the consultative committee set up by the Consistorium Major for subject teacher education and he functioned as the vice-chairman of the committee. Prof. Saarikko was also the director of the national physics student entrance board.

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

Prof. Juhani Keinonen (Prof. Markku Kulmala)
Prof. Heimo Saarikko (Prof. Hannu Koskinen)
(Prof. Hannu Savijärvi)
Doc. Keijo Hämäläinen (Doc. Niklas Meinander)
(Student Harri Waltari)

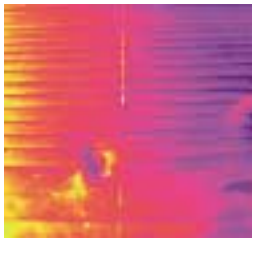
In the Faculty of Science the Department had members in the following bodies:

Faculty Planning Board: Prof. J. Keinonen (Student Harri Waltari was a vice member for students); Faculty Board for Developing Education: Prof. S. Manninen; Faculty Entrance Board: Prof. S. Manninen (chairman) and Doc. N. Meinander; Subject–teacher Student Entrance Board in the Faculty: Prof. H. Saarikko, vice chairman and Doc. B. Fant as a vice member; Subject–teacher Student Evaluation Board in Physics: Prof. H. Saarikko; Faculty and Kumpula Campus Library Boards: Prof. K. Eskola till 31.8./ Prof. A. Annila from 1.9.

Prof. Kari Eskola was the representative of the Faculty of Science in the library board of the Viikki Science Library. Professor Juhani Keinonen was a member of the Helsinki University Kumpula campus stage IV building committee.

In the Department the responsibility for surveying the various fields of activity have been divided as follows:

Budget: Prof. M. Kulmala; Job nominations: Prof. K. Eskola till 31.8./ Prof. K. Hämäläinen from 1.9.; International affairs: Doc. J. Niskanen (chairman), Prof. M. Chaichian, Student A. Ruhala and Student Emilia Koivisto; Student affairs: Prof. S. Manninen; Tutoring: Doc. I. Koponen; Education planning and development working group: Prof. S. Manninen (chairman), Prof. H. Saarikko, Doc. J. Niskanen, Kimmo Ruosteenoja till 31.3./Johanna Lauros from 6.5., Kai Rasmus, Student Noora Korhonen, Student Anna Ruhala and Student Maaria Tervo; Student selection: Prof. H. Saarikko (chairman), Prof. F. Stenman, Dr. S.M. Eskola and Student S. Vuorialho; Researcher education: Prof. K. Eskola (chairman) till 31.8. / Prof. A. Annila (chairman) from 1.9., Prof. K. Enqvist, S. Manninen, Doc. H. Kurki-Suonio, Prof. Timo Vesala and Student A.-M. Vitikainen; Open university: Prof. K. Eskola till 31.8.; Collaboration with senior secondary schools: Prof. J. Keinonen, Prof. K. Eskola till 31.8. and Prof. S. Manninen; working group writing the strategy of the Department of Physical Sciences: Prof. Markku Kulmala (chairman), Prof. Juhani Keinonen, Prof. Masud Chaichian, Prof. Matti Leppäranta, Doc. Ismo Koponen and Student Tuomas Lappi; Organizing Committee for the Summerschool: Prof. K. Eskola, Prof. C. Cronström, Prof. C. Montonen, Doc. E. Keski-Vakkuri, MSc O. Pasanen and Student A.-M. Vitikainen.



## TECHNICAL SUPPORT

The workshops of the Department have continued to provide high level support for research, development and teaching. There were no additions to the extant sophisticated equipment described in the 1996 Annual Report of the Department.

## 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 Netware servers. The Department has approximately 330 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 system which acts as a file server for both Linux and NT Windows workstations and also runs most of the programs the researchers use in their everyday work.

The “dynamo” mini-supercomputer cluster of the Department contains 16 work stations with 600 MHz Alpha EV67 processors running under the Linux operating system, and has proved to be highly useful for the high-performance computing needs of the researchers at the Department. Another Linux/Mosix cluster intended for high-performance computing has been set up utilizing the idle time (evenings, nights and weekends) of 60 student work stations (877 MHz Pentium III processors) which belong to the Kumpula Campus unit of the IT department. The most resource intensive simulations are still performed at the Center for Scientific Computing (CSC).

The Division of Atmospheric Sciences has about 110 PC and Alpha computers. The computers are used as workstations for researchers and laboratory and field measurements. A few of them are used as servers. All servers use either the Linux or UNIX operating system,

and about 50% of the workstations have Linux and 50% have Windows installed on them. Servers provide printing, Firewall, World Wide Web (www), File Transfer Protocol (ftp), Net File System (NFS), Server Message Block (SMB), Secure Shell (SSH), file, computing, database and backup services.

There are about 1100 registered users, both staff and students, on the university Unix mainframes and Netware servers. Each new student will get a computer account when enrolled in the University. The computer accounts are valid for one year, but can usually be prolonged, depending on the activity of the students.

## CAMPUS SERVICES

### Kumpula Science Library

www.kumpula.helsinki.fi/library/

The Kumpula Science Library was founded by the board of the Faculty of Science from the first of March 2001. The Science Library was formed by uniting the libraries and collections of the departments of Physics, Geophysics, Geology, Chemistry, Geography, Mathematics, Meteorology and Computer Science. The task of the Science Library is to promote research, teaching and studies in the fields of science on the Kumpula campus.

### Campus Unit of the IT Department

www.kumpula.helsinki.fi/atk

The services of the Campus Unit of the IT Department are directed to the researchers, personnel and students of the departments in Kumpula. The Campus Unit maintains the systems for the micro net (Huvikumpu, Hanko, Louhi) and the unix system (pcu) and the data communications. Also services such as micro classes, computer accounts and advice belong to our functioning.

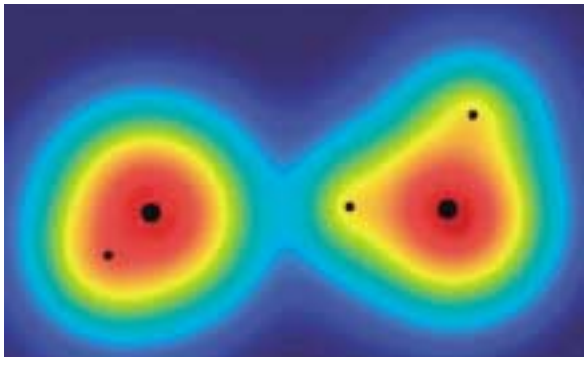
### Innovation Manager activity at Kumpula campus

From the beginning of 2002 Kumpula campus has had its own innovation manager, MSc (eng) Jari Rantala. In the new organization structure of the administrative office he belongs to the research services unit and is located in the Kumpula campus area, according to the new campus based thinking. The job description of the innovation manager is generally the promotion of the commercializing of the University's research based projects and counselling in matters of immaterial justice, contracts and financing. Conversations with the innovation manager are always strictly confidential.

In 2002, out of slightly over hundred project propositions put forward within Helsinki University about 30 came from the Kumpula campus. Many of these projects are still being developed further but at least some of them have already launched business activities around the initial idea. At the moment there are quite many tools for making business, finance and project planning, market analyses etc., for example HelsinkiTULI (www.culminatum.fi/tuli), the Spinno program (www.spinno.fi) and the VentureCup competition (www.finland.venturecup.fi). In urgent situations novelty and patentability research can be made through the innovation agent and the advisory service of the National Board of Patents and Registration (www.prh.fi). Company financing and support is available for example from the Employment and Economic Development Centre (www.tekeskus.fi), the National Technology Agency (www.tekes.fi) and capital investors like the Finnish National Fund for Research and Development (www.sitra.fi).

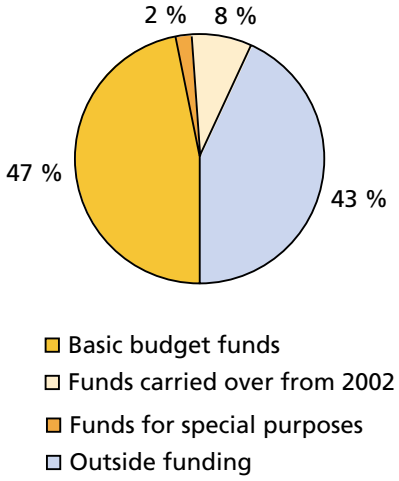
### Salary Unit of the Personnel Services and Kumpula Finances

The University personnel services branch office at Kumpula is located in the western part of the first floor of the Science Library. The unit is responsible for accounting of salaries for employees of the Faculty of Science, the Helsinki Institute of Physics, the Institute of Seismology and Verifin (Finnish Institute for the Verification of the Chemical Weapons Convention). There are 3 employees in the Salary Unit and the Kumpula Finances, each.

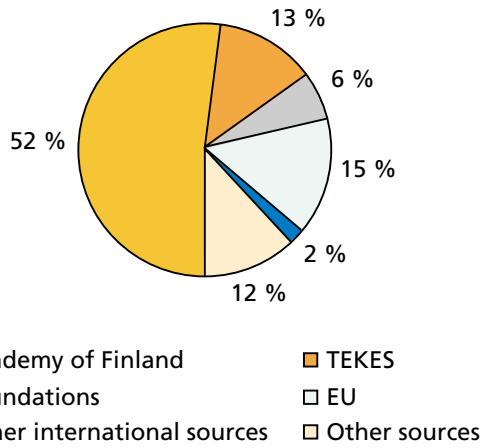


# Resources

## TOTAL FUNDING (10.05 M€)




## OUTSIDE FUNDING: NOT IN THE UNIVERSITY BUDGET (4.34 M€)

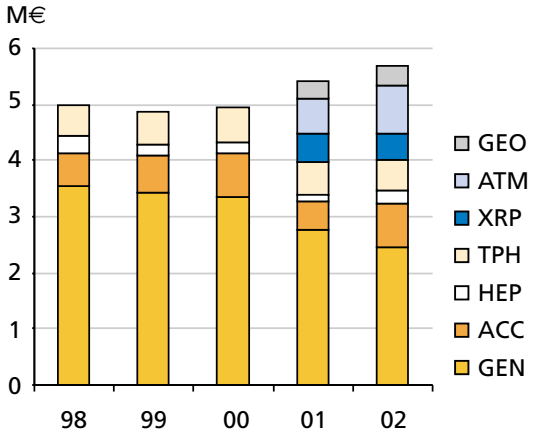



## FUNDING

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 47% of the whole funding of the Department; separate projects within the University contributed 2% and outside funding about 43%. The resources which came 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 1.80 M€. This sum is not included in the figures for funding. The salaries of the personnel of the Kumpula Science Library, and the rent of the premises of the library are financed by the Department of Physical Sciences by one quarter of the total expenses. These sums are not included in the figures for funding. The periodicals and books in physical sciences are paid by the Department.

Comprehensive budget funding for 2002 was 5.71 M€, 0.92 M€ of which was allocated for research and teaching equipment and for running costs, 3.73 M€ for salaries and the rest for project funding. The Department obtained 4.34 M€ from outside funds. Over half of that came from the Academy of Finland and the rest from many different sources, the most important of which were Tekes, EU, and foundations.

## BUDGET FUNDS




Budget funds (M€) in different divisions of the Department for 1998–02 (Note: the fusion took place in 2002)

## PERSONNEL

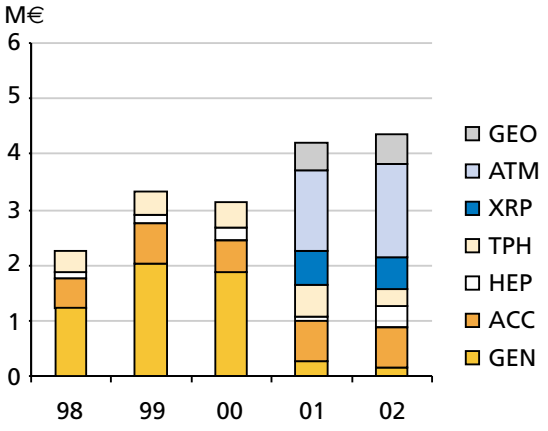
The personnel of the Department is listed in the Appendix. In December 2002 there were 104 posts for employment by budget funds, one of which was financed 45% by another institute (Finnish Meteorological Institute), another one third by the Department of Biosciences and one third by the Institute of Biotechnology and a third one 50% by the Finnish Institute of Occupational Health. Due to the ongoing changes in the structure of the teaching personnel all posts could not be kept filled during 2002. There were 25 professors (21.3 person-years) and 24 (15.7 person-years) other senior teaching posts (one lecturer, 10 university lecturers, and 13 senior assistants). There were additionally 20 (13.3 person-years) assistant posts for guiding laboratory practicals and problem sessions. The number of principally administrative posts on the staff was 16 (12.2 person-years) and that of technical employees 19 (16.2 person-years); in all 28.4 person-years.

In 2002 a total of 78.7 person-years were financed by budget funds and 127.5 person-years by outside funds. The latter included senior and junior researchers of the Academy of Finland, post-graduate students in the GS program, researchers financed via the EU and researchers on other projects financed by both private and state funds.

Fourteen students were chosen to work as summer trainees on state funds (HIP/CERN 3 posts, Finnish Meteorological Institute 2 posts in the Geophysical Research Division, Institute of Seismology 2, Finnish Centre for Radiation and Nuclear Safety 2, Finnish Institute of Marine Research 1, University of Uppsala, Molecular physics research group 1, University of Helsinki, Public Relations and Press Office 1, University of Helsinki, Department of Physical Sciences, Division of X-ray Physics 1 post and Division of Geophysics also 1 post).

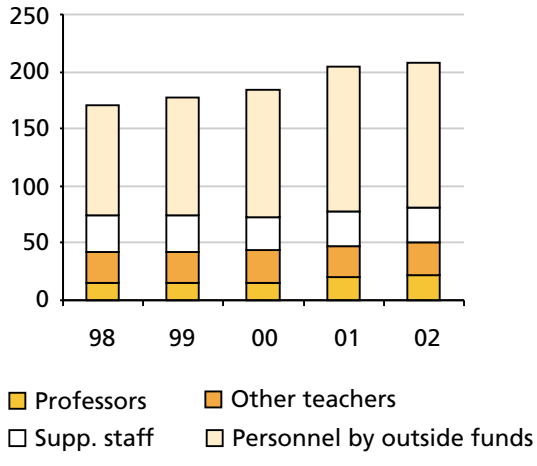
About 4.5 person-years were financed by the funds allocated to fee-for-service teachers.

## OUTSIDE FUNDING




Outside funding (M€) in 1998–02 in different divisions of the Department

## PERSONNEL




Total number of personnel in 1998–02 given in person-years

# Appendices

## PERSONNEL 2002

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

Head of Department
Keinonen, J., prof.

### Professors

*(annual total 21.3 person-years)*
Annila, A.
Chaichian, M.
Cronström, C.
Enqvist, K.
Eskola, K., retired from 1.9., locum 1.9.-31.12. Doc. S. Manninen
Green, A.M., h.c.
Hoyer, P., ol 1.1.-31.7.
Hämäläinen, K., from 1.9.
Kajantie, K., ol 1.8.-31.12., locum Doc. H. Kurki-Suonio
Keinonen, J.
Koskinen, H.
Kulmala, M.
Leppäranta, M., ol 1.8.-31.12.
Orava, R.
Paakkari, T., retired 1.6., locum 1.-31.8. Doc. K. Hämäläinen
Pesonen, L.
Riska, D.O., ol, locum Doc. C. Montonen
Saarikko, H.
Savijärvi, H.
Stenman, F.
Suortti, P.
Vesala, T.
1 vacancy, locum Doc. T. Huttula
1 vacancy, medical physics
1 vacancy, locum 1.9.-31.12. Doc. K. Hämeri

### University lecturers, doctor assistants and assistants

*(annual total 29.0 person-years)*

University lecturers
Ahlgren, T., Doc.
Bister, M., Doc., ol 1.1.-31.7., locum 5.10.-31.12. Doc. Ü. Rannik
Hæggström, E., Doc., ol from 15.1., locum 1.7.-31.12. Lic.Phil. J. Aaltonen
Hämäläinen, A., Dr.
Kurki-Suonio, H., Doc., ol 1.8.-31.12.
Manninen, S., Doc., ol 1.9.-31.12.
Rauhala, E., Doc.
Rummukainen, K., Doc., ol 1.1.-31.8.
Österberg, K., Dr.
1 vacancy, locum 1.8.-31.12. Doc. J. Niskanen
1 vacancy

Senior assistants
(according to the old job structure)
Fant, B., Doc.
Koponen, I.T., Doc.
Nordlund, K., Doc., ol
Pietarinen, E., Doc., ol, locum 1.1.-31.7. MSc V.-M. Tiainen
Ruosteenoja, K., Doc., ol from 1.4., locum 1.9.-31.12. Dr. M. Olin
Serimaa, R., Doc.
1 vacancy, locum 1.1.-31.7. Doc. K. Lehtinen, 1.8.-31.12. Dr. I. Napari
1 vacancy, locum 1.1.-31.7. Dr. J. Laukkanen
1 vacancy till 31.8., locum 1.1.-31.7. Doc. J. Niskanen

Doctor assistants
Arstila, K., Dr.
Torkkeli, M., Dr.
Vainio, R., Doc., ol 1.1.-31.7.
1 vacancy

Assistants
(according to the new job structure)
Donadini, F., MSc
Hämeri, K., Doc., ol
Rasmus, K, MSc
Räisänen, P., Dr., ol

Assistants in locum positions
(according to the old job structure)
Bogdan, A., Dr., 4 mo
Eriksson, S., Dr., 6 mo
Edelmann, E., MSc, 7 mo
Galambosi, S., MSc, 12 mo
Heikkinen, M., MSc, 5 mo
Hölttä, T., MSc, 7 mo
Karppinen, T., Lic.Phil., 12 mo
Koponen, I.K., MSc, 5 mo
Korpelainen, V., MSc, 3.5 mo
Leskinen, M., MSc, 9 mo
Lintunen, J., MSc, 7 mo
Malvikko, S.-P., MSc, 2 mo
Merikanto, J., MSc, 5 mo
Niemelä, S., MSc, 12 mo
Puustinen, A., MSc, 7 mo
Sajavaara, T., Dr, 6 mo
Salmi, P, MSc, 5 mo
Salonen, E., Dr., 4 mo
Sevanto, S., MSc, 7 mo
Soininen, Antti, MSc, 5 mo
Tiainen, V.-M., MSc, 5 mo
16 vacancies

### Supportive administrative and technical staff

*(annual total 28.4 person-years)*

Technical personnel
*(annual total 16.2 person-years)*
. Laboratory managers
Blomberg, M., Doc.
Paatero, P., Doc., ol, locum MSc J. Hienola
Puhakka, T., Doc.
Ståhlberg, B., Doc.
Tikkanen, P., Doc., ol 9.5.-12.8., locum MSc V. Palonen
Vikberg, S., MSc
Wahlström, K., eng.
1 vacancy

. Other technical staff
Engström, P., general technician
Ingren, R., BSc, laboratory technician
Kortesmaa, J., general technician, from 1.4.

Kousa, S., eng., laboratory technician
Kurki, M., laboratory technician, ol 0.5 mo
Pekki, I., laboratory technician
Pihkala, P., laboratory technician
Sariola, S., laboratory technician
Sepponen, H., chief technician
Siiki, P., laboratory technician
Urkio, J., technician, till 17.6.

Administrative personnel
*(annual total 12.2 person-years)*

Ahonen, J., MSc, secretary, ol 1.2.-31.12., locum 1.2.-31.3. MSc P. Mikkonen, 19.8.- 31.10. BSc M. Tikka
Antila, U., secretary
Arponen, J., Doc., amanuensis, ol 24.6.-31.12., locum 1.-31.12. (60%) MSc A. Wallin
Hyvönen-Dabek, M., Doc., aman.
Kivinen, M., senior secretary, ol, locum S. Ranta-Haatanen till 31.7.
Koivisto, L., secretary
Laitinen, M., MSc, aman.
Louhio, M.-L., senior secretary
Montonen, C., Doc., aman., ol, locum MSc T. Raita
Pitkänen, T., senior secretary
Sundius, T., Doc., aman.
Uurinmäki, S., senior secretary, ol 28.10.-30.11.
Vahvaselkä, A., Dr., aman.
1 vacancy, locum 1.1.-28.2. & 1.6.-31.12. Lic.Phil. S. Andersson
1 vacancy, amanuensis

## Personnel supported by external funds

*(annual total 127.5 person-years)*

General Division
*(annual total 14.0 person-years)*

. Didactical Physics Unit
*(annual total 5.3 person-years)*
Hannula, I., MSc, 2 mo
Heikkinen, M., MSc, 6 mo
Hendolin, I., student, 4 mo
Karhunen, L., MSc, 12 mo
Kirkkala, S.-R., student, 3.5 mo
Lepola, J., student, 7 mo
Mannila, K., MSc, 2 mo
Mäntylä, née Kortesniemi, T., student, 12 mo
Saloranta, S., student, 3 mo
Turunen, H., student, 8 mo
Vuorialho, S., student 4.5 mo

. Electronics Research Unit
*(annual total 2.8 person-years)*
Aaltonen, J., Lic.Phil., 6 mo
Forsman, née Nyman, P., MSc, 3 mo
Hassinen, T., student, 5 mo
Kassamakov, I., PhD, 9 mo
Kelloniemi, A., student, 1 mo
Luhtakanta, S., student, 7 mo
Matalamäki, K., student, 2 mo

. Medical Physics
*(annual total 2.1 person-years)*
Hippeläinen, E., student, 3 mo
Koivunoro, H., MSc, 1 mo
Ryynänen, P., MSc, Bachelor of Medicine (BM), 3 mo
Seppälä, T., MSc, 1.5 mo
Timonen, M., student, 8.5 mo
Uusi-Simola, J., BSc, 8 mo

. Space Physics
*(annual total 3.8 person-years)*
Honkkila, V., MSc, 12 mo
Huttunen, E., MSc, 12 mo
Lintunen, J., student, 5 mo
Partamies, N., MSc, 12 mo
Tanskanen, E., Dr., 5 mo

. Theoretical Nuclear Physics
*(annual total 0.8 person-years)*
Helminen, C., Dr., 10 mo

Accelerator Laboratory Division
*(annual total 24.8 person-years)*

Alakoski, E., MSc, 12 mo
Blomqvist, J., Dr., 5 mo
Dayioglu, S., student, 4 mo
Edelmann, E., MSc, 5 mo
Eriksson, S., Dr., 6 mo
Frantz, J., MSc, 12 mo
Fordell, Th., MSc, 4 mo
Harjunmaa, A., student, 9 mo
Heinola, K., student, 11 mo
Henriksson, K., MSc, 6.5 mo
Hildén, T., student, 3 mo
Juslin, N., student, 3.3 mo
Järvi, N., student, 1.8 mo
Kalliokoski, M., student, 3 mo
Kiuru, M., MSc, 12 mo
Krasheninnikov, A., PhD, 12 mo
Lakio, A., student, 2 mo
Lindberg, Å., Doc., 5 mo
Mattila, O.-P., student, 3 mo
Mehtälä, M., student, 3 mo
Meinander, K., student, 6.5 mo
Mizohata, K., MSc, 12 mo
Nord, J., MSc, 12 mo
Nordlund, K., Doc., 12 mo
Oljemark, F., student, 3 mo
Palonen, V., MSc, 9 mo
Peltola, J., MSc, 12 mo
Pomoell, J., student 3.3 mo
Pusa, P., MSc, 12 mo
Reijonen, V., student, 3.3 mo
Riipinen, I., student, 2 mo
Ruhala, A., student, 7.3 mo
Rusanen, M., MSc, 12 mo
Rydman, W., MSc, 12 mo
Sajavaara, T., Dr., 6 mo
Salonen, E., Dr., 8 mo
Salonen, M., student, 3 mo
Soininen, Antti, MSc, 4 mo
Tarus, J., Dr., 7 mo
Träskelin, P., student, 7.5 mo
Valling, S., student, 4 mo
Virdi, G.S., PhD, 8 mo
Vitikainen, A.-M., student, 3 mo
Väyrynen, A., student, 3.5 mo
Zibellini, A., student, 3 mo

High Energy Physics Division
*(annual total 4.5 person-years)*

Alavi, S.A., PhD, 6 mo
Andric, I., Prof., 0.5 mo
Berezhiani, Z., Prof., 1 mo
Cabo, A., Prof., 0.6 mo

# Appendices

Carey, A., Prof., 0.5 mo
Chkareuli, J., Prof., 1 mo
Chen, W., PhD, 2 mo
Ellinas, D., PhD, 0.5 mo
Harun-or-Rashid, S.M., Dr., 3 mo
Kobakhidze, A., PhD, 5.5 mo
Kulish, P., Prof., 0.1 mo
Liao, Y., PhD, 0.6 mo
Michelsson, J., Prof., 0.5 mo
Mnatsakanova, M., PhD, 0.7 mo
Nishijima, K., Academician, 0.5 mo
Petrov, V., Prof., 0.5 mo
Presnajder, P., Prof., 3.5 mo
Tureanu, A., MSc, 12 mo
Törnqvist, N.A., Doc., 12 mo
Vernov, Y., Prof., 0.7 mo

Theoretical Physics
*(annual total 14.2 person-years)*

Adzhemyan, L., Prof., 2 mo
Antonov, N., DSc, 2.5 mo
Gynther, A., MSc, 12 mo
Henttu, J., student, 2.3 mo
Hietanen, A., student, 2 mo
Högdahl, J., student, 3 mo
Jahma, M., MSc, 2 mo
Kajantie, K., Prof., 5 mo
Kalliomäki, A., MSc, 12 mo
Keihänen, née Sihvola, E., Dr., 12 mo
Kompaniets, M., MSc, 1 mo
Koponen, J., MSc, 12 mo
Lappi, T., MSc, 6 mo
Muhonen,V., student, 3 mo
Nalimov, M., DSc, 1 mo
Piirola, P., MSc, 12 mo
Pismak, Yu., Prof., 2.8 mo
Poutanen, T., MSc, 12 mo
Salmela, A., MSc, 12 mo
Sipiläinen, V., MSc, 12 mo
Sorri, A., Dr., 6 mo
Vepsäläinen, M., MSc, 6 mo
Vuorinen, A. MSc 12 mo
Väihkönen, A., MSc, 3 mo
Väliviita, J., MSc, 12 mo
Wycech, S., 1 mo

X-ray Division
*(annual total 15.7 person-years)*

Andersson, S., Lic.Phil., 3 mo
Fernandez, M., MSc, 12 mo
Harjunmaa, J., student, 8 mo
Huotari, S., MSc, 12 mo
Hämäläinen, K., Doc., 7 mo
Ikonen, T., MSc, 12 mo
Jääskeläinen, P., student, 7.5 mo
Keyriläinen, J., MSc, 7 mo
Kisko, K., student, 12 mo
Koponen, T., student, 12 mo
Laakso, T., student, 9 mo
Lassila, I., student, 3 mo
Laukkanen, J., Dr., 5 mo
Mattila, A., MSc, 12 mo
Morlanes, J., student, 3.5 mo
Nygård, K., MSc, 12 mo
Peura, M., MSc, 12 mo
Porra, L., MSc, 12 mo
Sarén, M., student, 12 mo
Suhonen, H., student, 3 mo
Vainio, U., student, 12 mo

Division of Atmospheric Sciences
*(annual total 43.4 person-years)*

Aalto, P., MSc, 12 mo
Adler, H., student, 12 mo
Ahola, I., MSc (Agro For) 0.5 mo
Airaksinen, S., student, 4 mo
Altimir Escale, N., MSc, 12 mo
Auvinen, A., MSc (Tech.), 0.5 mo
Bogdan, A., Dr., 8 mo
Boy, M., MSc, 12 mo
Dal Maso, M., MSc, 12 mo
Gaman, A., MSc, 12 mo
Grönholm, T., 12 mo
Haikonen, J., student, 3 mo
Hautio, K., 4 mo
Herrmann, E., student, 12 mo
Hiltunen, V., MSc, 12 mo
Huotari, J., student, 9 mo
Hussein, T., MSc, 12 mo
Jokiniemi, J., Dr., 0.5 mo
Kalakoski, N., 1 mo
Kallonen, J., student, 1 mo
Kauhanen, J., MSc, 12 mo
Keronen, P., MSc, 12 mo
Koponen, I.K., MSc, 7 mo
Korhonen, H., MSc, 12 mo
Kulmala, Mikko, 0.3 mo
Kurtén, Th., 1 mo
Kuuspalo, K., MSc, 8 mo
Laakso, L., MSc, 12 mo
Lauri, A., MSc, 12 mo
Lauros, J., MSc, 12 mo
Lehtinen, K., Dr. Tech., Doc., 5 mo
Leskinen, M., MSc, 3 mo
Linkosalo, T., Dr. (Agro For), MSc, 12 mo
Lushnikov, A., Prof., 2 mo
Markkanen, T., MSc, 12 mo
Määttänen, A., MSc, 10 mo
Mönkkönen, J., MSc, 11 mo
Napari, I., Dr., 7 mo
Niemi, J., student, 4 mo
O'Dowd, C., PhD, 7 mo
Olin, M., Doc., 6 mo
Paatero, P., Doc., 12 mo
Peltomaa, E., student, 5 mo
Petäjä, T., student, 12 mo
Pihlatie, M., MSc, 12 mo
Pirazzini, R., MSc, 5 mo
Puustinen, A., MSc, 5 mo
Raittila, J., student, 9 mo
Raivonen, M., student, 6 mo
Rannik, Ü., Doc., 11 mo
Reissell, A., Dr., 8 mo
Ruotsalainen, R., student, 8 mo
Ruuskanen, T., student, 8 mo
Sevanto, S., MSc, 5 mo
Shimmo, M., MSc, 12 mo
Siivola, E., MSc (Techn), 12 mo
Simojoki, A., Dr. (Agro For), 8.5 mo
Strahlendorff, M., student, 6 mo
Suni, T., MSc, 12 mo
Tisler, P., Lic.Phil., 12 mo
Vartiainen, E., 2 mo
Vehkamäki, H., Doc., 12 mo
Väkevä, M., Dr., 1 mo
Winkler, P., MSc, 12 mo
Zapadinsky, E., Dr., 6 mo

Geophysics Division
*(annual total 9.8 person-years)*

Blanco Sequeiros, J., MSc, 1 mo
Ehn, J., MSc, 12 mo
Granskog, M., MSc, 12 mo
Haapala, J., Doc., 11 mo
Herlevi, A., MSc, 6.5 mo
Huttunen, O., student, 3 mo
Kuulusa, M., MSc, 5 mo
Kärkäs, E., MSc, 12 mo
Leppäranta, M., Prof., 5 mo
Luodekari, K., student, 2 mo
Lönnroth, N., MSc, 12 mo
Lindfors, A., MSc, 11 mo
Nordlund, M., student, 2 mo
Rasmus, S., MSc, 12 mo
Salminen, J., student, 5 mo
Virkkunen, A., student, 2.5 mo
Wang, K., MSc, 8 mo

## Teachers from other institutions

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

Ahtee, M., Prof., University of Jyväskylä, Department of Teacher Education
Goldstein, R., Prof.
Heikkinen, P., Dr., Director, Institute of Seismology
Heikkonen, J., Doc., Helsinki University Central Hospital
Heino, R., Doc., Finnish Meteorological Institute
Honkonen, J., Doc., National Defence College
Huitu, K., Doc., Helsinki Institute of Physics
Kallunki, V., MSc, Univ. lecturer, Univ. Helsinki, Department of Teacher Education, Class Teacher Section
Kerminen, V.-M., Prof., Finnish Meteorological Institute
Koistinen, J., MSc, Finnish Meteorological Institute
Konschin, H., Dr., Department of Chemistry
Kukkonen, I., Dr. Tech., Doc., Geological Survey of Finland
Kurki-Suonio, K., Prof. emer.
Lushnikov, A., Prof., Karpov Institute of Physical Chemistry, Moscow
Moore, J., PhD, Doc., University of Lapland
Nikkinen, P., Doc., Helsinki University Central Hospital
Ollikainen, M., Dr., Finnish Geodetic Institute
Peltoniemi, M., Prof., Helsinki University of Technology
Pennanen, P., Dr.
Pirjola, L., Doc., Helsinki Polytechnic
Poutanen, M., Prof., Finnish Geodetic Institute
Saarelainen, S., Doc., VTT (Technical Research Centre of Finland)
Sainio, M., Doc., Helsinki Institute of Physics
Savolainen, S., Doc., Helsinki University Central Hospital
Tarvainen, M., Dr., Institute of Seismology
Tenhunen, M., Doc., Helsinki University Central Hospital
Tiira, T., Dr., Institute of Seismology
Tuma, R., Doc., Department of Biosciences
Vermeer, M., PhD, Prof., Helsinki University of Technology
Viljanen, A., Dr., Finnish Meteorological Institute
Vuohelainen, R., Dr., Mikkeli Polytechnic

# Appendices

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Edited by Mervi Hyvönen-Dabek
Language substantially revised by Jan Dabek

ISSN 0781-4038
HELSINKI 2003
HELSINKI UNIVERSITY PRESS
UNIVERSITY PRINTING HOUSE

Artistic design and layout Reija Jokinen, Helsinki University Press

University of Helsinki
Department of Physical Sciences