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EVALUATION REPORT

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Members of the Evaluation Panel

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ACADEMY OF FINLAND

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Appendices

DESCRIPTION

Publisher	Academy of Finland	Date September 2012
Author(s)	Evaluation panel (ed. Dr Mikko Lensu)	
Name of publication	Physics Research in Finland 2007–2011. Evaluation Report	
Abstract	This report presents an international evaluation of physics research in Finland. The evaluation panel included professors Christian Enss (Chair), Angela Bracco, Jörg Büchner, Franco Cacialli, Hans-Friedrich Graf, Ulf Karlsson, Finn Ravndal and Clare Yu. The evaluation includes 30 physics units and covers the period 2007–2011. The panel based its assessment on forms filled by the units, and on interviews conducted on 5–11 May 2012. The aim was to evaluate the quality of physics research and its subfields as compared to international standards. The panel was asked to provide a critical assessment of each unit, give recommendations for the future and pay attention to research infrastructures. The report presents the panel's observations and recommendations in three main parts. Part I considers the field of physics in general, covering issues of quality and scope, funding, recruitment, PhD training, societal relevance and internationalisation. Part I also discusses research infrastructures and gives recommendations to the Academy of Finland and the Ministry of Education, Science and Culture. Part II looks at the subfields: atmospheric physics, biological physics, computational physics, condensed matter and materials physics, high-energy physics, nuclear physics, optics and photonics, and space physics. Part III consists of the evaluations of the units. The panel found that the quality of Finnish physics research is generally high, with very successful or even internationally leading units. However, a number of units of subcritical size would benefit from efficient strategies to free their hidden potential. The research covers most major international trends with little need for introducing new directions through external measures. However, at the same time, the funding policies should be nimble enough to allow for the pursuit of emerging fields. The funding situation is generally satisfactory, though the proportion of competitive funding is already too high, and an increase in stable core funding would allow for a bolder seizing of long-term opportunities. The lack of administrative support was recognised as a general problem. The recruitment policies are approaching international standards, but the panel recommends that more start-up funds be made available for pursuing new areas and attracting top-level foreign scientists. The quality of PhD education is good, thanks to national doctoral programmes, but the panel was concerned about how this level will be maintained after the planned changes to the system. The research infrastructure was seen as quite good; there are several outstanding facilities but also units with outdated equipment.	
Keywords	physics, evaluation, research funding, atmospheric physics, biological physics, computational physics, materials physics, condensed matter physics, high-energy physics, nuclear physics, optics, photonics, space physics	
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KUVAILULEHTI

Julkaisija	Suomen Akatemia	Päivämäärä Syyskuu 2012
Tekijä(t)	Arviointipanelin jäsenet (toim. FT Mikko Lensu)	
Julkaisun nimi	Physics Research in Finland 2007–2011. Evaluation Report	
Tiivistelmä	Kansainvälinen arviointipaneeli on arvioinut Suomen fysiikan alan tutkimuksen tason. Paneelin jäseninä toimivat professorit Christian Enss (pj), Angela Bracco, Jörg Büchner, Franco Cacialli, Hans-Friedrich Graf, Ulf Karlsson, Finn Ravndal ja Clare Yu. Arviointi käsitti 30 yksikköä ja jakson 2007–2011. Paneelin arviot perustuivat yksiköiden tekemiin itsearviointeihin sekä toukokuussa 2012 tehtyihin haastatteluihin. Tarkoituksena oli arvioida fysiikan tutkimuksen ja sen osa-alueiden taso ja verrata sitä kansainväliseen tasoon. Paneelia pyydettiin myös arvioimaan jokainen yksikkö erikseen, antamaan suosituksia tulevia linjauksia varten sekä kiinnittämään erityistä huomiota tutkimuksen infrastruktuureihin. Raportti sisältää paneelin havainnot ja suositukset ja siinä on kolme pääosiota. Ensimmäinen osa tarkastelee fysiikan alaa kokonaisuutena ja käsittelee laatua ja kattavuutta sekä rahoitukseen, henkilöstöön, tohtorikoulutukseen, yhteiskunnalliseen merkittävyyteen ja kansainvälisyyteen liittyviä kysymyksiä. Myös tutkimusinfrastruktuureja tarkastellaan ja suosituksia annetaan myös Suomen Akatemialle sekä opetus- ja kulttuuriministeriölle. Toinen osa tarkastelee seuraavia fysiikan osa-alueita: ilmakehän fysiikka, biologinen fysiikka, laskennallinen fysiikka, materiaali- ja tiiviin aineen fysiikka, hiukkas- ja ydinfysiikka, optiikka ja fotoniikka, sekä avaruusfysiikka. Kolmas osa sisältää yksiköiden arvioinnit. Paneelin näkemyksen mukaan fysiikan taso on Suomessa varsin korkea. Eräät yksiköt ovat erittäin menestyneitä tai jopa kansainvälisesti johtavia alallaan, mutta monet pienet yksiköt hyötyisivät voimavarojensa suunnitelmallisemmasta suuntaamisesta. Tutkimuksen kenttä kattaa keskeiset kansainväliset aiheet eikä siinä ole varsinaisia puutteita, mutta rahoituksen tulisi myös tukea orastavia tulevaisuuden aloja. Rahoitustilanne on yleensä ottaen hyvä, mutta ulkoisen rahoituksen osuus on kasvanut liian suureksi. Budjettirahoituksen osuuden lisääminen mahdollistaisi rohkeammat aloitteet uusilla aloilla, joiden merkittävyys ilmenee vasta pitemmällä aikavälillä. Yleisenä ongelmana nähtiin hallinnollisen tuen puute. Tutkijoiden värväyksessä lähestytään kansainvälisiä käytäntöjä, mutta paneeli suositti starttirahoitusta uusien alojen avaamiseksi ja ulkomaisten huippututkijoiden houkuttamiseksi. Tohtorikoulutuksen tasoa pidettiin korkeana, mutta paneeli oli myös huolissaan suunnitellun tutkijakoulujärjestelmän remontin vaikutuksista. Tutkimusinfrastruktuurien taso on myös varsin hyvä ja joiltain osin erinomainen. Toisaalta löytyy myös yksikköjä, joiden tutkimus kärsii vanhentuneista laitteistoista.	
Asiasanat	fysiikka, arviointi, tutkimusrahoitus, ilmakehäfysiikka, biologinen fysiikka, laskennallinen fysiikka, mate-riaalifysiikka, tiiviin aineen fysiikka, hiukkasfysiikka, ydinfysiikka, optiikka, fotoniikka, avaruusfysiikka	
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PRESENTATIONSBLAD

Utgivare	Finlands Akademi	Datum September 2012
Författare	Utvärderingspanel (red. FD Mikko Lensu)	
Publikationens namn	Physics Research in Finland 2007–2011. Evaluation Report. (Utvärdering av fysikforskning i Finland 2007–2011)	
Sammandrag	Denna rapport presenterar en internationell utvärdering av den finländska forskningen i fysik åren 2007–2011. Utvärderingspanelen bestod av professorerna Christian Enss (ordf.), Angela Bracco, Jörg Büchner, Franco Cacialli, Hans-Friedrich Graf, Ulf Karlsson, Finn Ravndal och Clare Yu. Utvärderingen omfattade 30 enheter inom fysikforskning. Panelens omdömen grundar sig på material som enheterna själv lämnat in samt på intervjuer som genomfördes i maj 2012. Målet var att granska fysikforskningens nivå i Finland och jämföra den internationellt. Panelen fick dessutom i uppgift att utvärdera varje enhet skilt, ge rekommendationer för framtiden och fästa särskild uppmärksamhet vid forskningens infrastruktur. Rapporten presenterar panelens observationer och rekommendationer i tre huvuddelar. Del 1 granskar området fysik i sin helhet ur flera olika synvinklar: kvalitet och omfång, finansiering, personal, doktorsutbildning, samhälleligt genomslag och internationalism. Panelen undersöker dessutom forskningens infrastruktur och ger rekommendationer till Finlands Akademi och undervisnings- och kulturministeriet. I del 2 granskas fysikens olika delområden: atmosfärfysik, biologisk fysik, beräkningsfysik, material- och kondenserade materiens fysik, partikelfysik, kärnfysik, optik och fotonik, samt rymdfysik. Del 3 innehåller enhetsutvärderingarna. Enligt panelen håller fysikforskningen i Finland mycket hög nivå. Vissa forskningsenheter är tämligen framgångsrika eller rent av internationellt ledande på sitt område, men det finns också små enheter som skulle ha nytta av att rikta sina resurser på ett mer systematiskt sätt. Forskningsfältet täcker de viktigaste internationella delområdena utan större brister, men finansieringen borde också stödja nya, växande områden. Finansieringssituationen är överlag bra, men den externa finansieringens andel har blivit för stor. En ökning av budgetfinansieringens andel kunde hjälpa forskare att göra modigare initiativ inom nya områden vars betydelse syns på lång sikt. Panelen identifierar bristen på administrativt stöd som ett allmänt problem. Rekryteringen börjar närma sig internationell praxis, men panelen rekommenderar ändå att startfinansiering tas i bruk för att öppna upp nya områden och locka till sig utländska toppforskare. Doktorsutbildningen håller hög kvalitet, men panelen är också oroad över effekterna av den planerade omorganiseringen av forskarskolesystemet. Även forskningens infrastrukturer är av mycket hög kvalitet, men det finns vissa enheter där en föråldrad utrustning inverkar negativt på resultaten.	
Nyckelord	fysik, utvärdering, forskningsfinansiering, atmosfärfysik, biologisk fysik, beräkningsfysik, materialfysik, kondenserade materiens fysik, partikelfysik, kärnfysik, optik, fotonik, rymdfysik	
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PREFACE

This report, conducted by an international panel that was assembled and appointed by the Academy of Finland, is the result of an evaluation of the status of physics research in Finland between 2007 and 2011. The evaluation was carried out as part of regular assessments of all fields of science in Finland. Physics is a particularly wide and diverse field, which makes such an evaluation for an entire country a very challenging task. Based on the general practice of the Academy in previous assessments, a procedure was proposed and discussed openly in detail with the steering group in early spring 2012. The members of the steering group made it very clear from the beginning that these modalities are by no means fixed and that the panel could make adjustments were it saw fit. The panel is thankful to all of the members of the steering group, Janne Ignatius, Asta Kärkkäinen, Veli-Pekka Leppänen, Erkki Oja (chair) and Lassi Päivärinta, for their genuine interest in the view of the panel as well as for their support and encouragement.

Such a report is in some ways a snapshot in time compiled from various sources. In this evaluation, there were on-site unit visits with laboratory tours and extended hearings, as well as retrospective data that were gathered independently by the Academy prior to the hearings. The panel would like to express its thanks to Samuli Hemming, Henriikka Kekäläinen and Pentti Pulkkinen for taking care of all practical arrangements during the week of the on-site visits. Given the ambitious schedule of the hearings, the logistics had to be just perfect and it was. Many thanks also to the coordinator of this evaluation, Mikko Lensu, who supported and helped the panel in all phases of this evaluation with his patience and competence.

For all of the panel members, the evaluation was a very interesting endeavour in which many new insights were gained. At the same time, it was a great challenge in which the panel was now and then pushed to its physical limits during the week of the hearings. The panel would like to thank all units for their participation in very constructive hearings, and for their time and efforts throughout the evaluation process. The recommendations and conclusions stated in this report are based on an honest effort to be factually correct, but they, of course, ultimately reflect the opinion of the panel members. The members certainly hope that the report will be viewed as a fair assessment and will provide a constructive basis for improvement and for advancing physics research in Finland.

EXECUTIVE SUMMARY

The quality of physics research in Finland is generally very high and many of the units evaluated for this report are strong competitors on an international level. Given the size of the country, the number of extremely successful physics research groups is certainly impressive. It seems that in particular the groups involved in Centres of Excellence (CoE) are doing very well, although there are also groups outside such centres that are very successful. The observation that groups in CoEs perform well is not surprising, because they must have been excellent in the first place to be selected as a CoE. In addition, CoEs naturally have critical mass and, typically, far better research environments. The evaluation panel sees the CoE Programme as a successful funding instrument. However, it should be well balanced with sufficient support for individual groups, which is lacking in some places at present. At several universities, there are groups and units of subcritical size that in the current situation have little hope of improving in the future. In these cases, a thoughtful, long-term appointment policy and funding strategy is needed to fix these structural deficits. This is a vast additional potential for physics research that could be realised in the future if it is done right.

In terms of the overall amount of funding, the situation is for most units satisfactory. However, the funding seems, in many cases, too fractured, and the proportion of competitive funding is generally quite large. Although the panel supports that a certain portion of the funding should be obtained in a competitive way, it is concerned about the fact that the emphasis on this type of funding is currently too large, which results in the risk that long-term goals are somewhat disregarded and potential opportunities are missed. The units need a substantial amount of stable core funding to maintain their competence through excellent infrastructures and to allow them to keep the necessary level of qualified staff. It should also be seen that competition-driven funding always involves additional time and work that could be better spent on research. A general problem at Finnish universities is the lack of qualified administrative support. Especially in funding applications and the handling of grants, too much rests on the shoulders of individual researchers, who have neither the optimal qualifications nor the time to do this. At first glance, it might seem advantageous and cost-efficient to slim down administration as much as possible, which is a tendency in many countries and institutions, but it often just redistributes the work and burdens researchers who are better qualified to do something else. Qualified administrative support can enhance the efficiency of research and teaching enormously.

Looking at the current spectrum of research topics in the field of physics in Finland, it is clear that most major international trends are represented in a well-balanced way. There is sufficient diversity and also some clear focus areas, such as nanophysics, which is found at almost every university in some form. Currently, there seems to be no need to stimulate specific research directions on a national level. However, the system needs to be nimble enough to pursue new emerging research areas such as biological physics.

All Finnish universities seem to have proper recruitment procedures in place and recruit internationally. In spite of this, it seems that only a small fraction of academic positions is filled by top-level foreign scientists. There is room for improvement in this respect. To realise this potential, special efforts are needed from universities to attract such leading international figures. At some universities, offers are rather limited, in particular in terms of start-up funds, which makes it difficult to be competitive for the best possible candidates. In general, there is a trend to have more tenure-track positions, but the details are quite different between universities, sometimes even a bit confusing. It would be beneficial to have a nationwide, more uniform tenure-track system with clear and standardised operating conditions. In addition, start-up funds should be provided to new assistant professors to enable them to pursue new areas of research.

Overall, the infrastructure of the evaluated units is quite good and in many cases of high international standard. There are some outstanding large-scale infrastructures that have been built and maintained by Finnish groups. Recently, several of these facilities have been recognised as national-level infrastructures: CRYOHALL, CSC, JYFL-ACCLAB, Micronova and SMEAR. Finnish groups are also involved in a number of international infrastructures such as CERN, ESRF and FAIR. Overall, the contributions made by those groups are very good. Also, at the laboratory level, most units are well equipped. There are only some universities where the equipment of some groups seems to be far outdated and clearly needs upgrading. This is often directly related to questions about the general future of such units. In these cases, the situation has to be analysed carefully and an overall strategic plan be put in place.

There are some 500 physics PhD students in Finland. Given the population, this seems to be a rather small number. In general, the PhD students are well trained and, in most cases, appear to do excellent research. The time to obtain a PhD in physics varies quite a bit depending on the university and the physics field, and is between three and seven years. Currently, PhD training is organised for specific subfields in national doctoral training programmes, to make use of the resources nationwide. These national doctoral programmes and Tekes provide the funding in most cases. This system seems to work well, but it will nevertheless be replaced by a system where the universities organise the training and provide the funding locally. At this point, it is not clear whether this will have positive or negative effects.

There are a number of ways in which physics research impacts Finnish society. There are many collaborative projects with industry that have direct relevance in the development of new products. Basic research often needs specific tools that have to be developed by the research groups and, in some cases, this will eventually lead to commercial products. The number of spin-off companies is quite high in Finland and indicates that the pipeline between basic research and the commercial market is working well. In addition, students graduating in physics from Finnish universities are well educated and easily find jobs in a wide spectrum of sectors. From this point of view, measures that lead to an increase in students, and thereby in physics graduates, would seem reasonable. While there are some universities that have public outreach activities, this is an area in which much more could and should be done.

1 INTRODUCTION

1.1 Panel members

Christian Enss, the chair of the panel, is Professor of Experimental Physics at the Department of Physics and Astronomy of Heidelberg University, Germany.

Angela Bracco is Professor of Experimental Nuclear Physics at the Department of Physics of the University of Milan, Italy.

Jörg Büchner is a professor heading the Theory and Simulation of Solar System Plasmas group at the Max Planck Institute for Solar System Research, Germany.

Franco Cacialli is Professor of Physics at the Department of Physics and Astronomy and the London Centre for Nanotechnology of University College London, UK.

Hans-Friedrich Graf is Professor of Environmental Systems Analysis at the Department of Geography of the University of Cambridge, UK.

Ulf Karlsson is Professor of Materials Physics at the School of Information and Communication Technology of the Royal Institute of Technology, Sweden.

Finn Ravndal is Professor of Theoretical Physics at the Department of Physics of the University of Oslo, Norway.

Clare Yu is Professor of Physics and Astronomy at the Department of Physics and Astronomy of the University of California, Irvine, USA.

1.2 Background of the evaluation

In 2011, the Academy of Finland's Research Council for Natural Sciences and Engineering decided to conduct an international evaluation of publicly funded physics research in Finland. A major motivation was that the field of physics has been in a state of rapid change that is likely to continue in the future. Besides the increase in volume, the field has grown more diverse and the boundaries between neighbouring fields of research have become diffuse. The situation is much more complicated now than it was ten years ago, when all Academy applications in physics could be evaluated by a single expert panel. The Research Council wanted especially to get a better understanding of the status of fundamental physics research and of how its resources have developed. The Research Council was also interested in the sustainability of national physics infrastructures and in the prospects of future participation in large-scale international infrastructure projects beyond CERN. As the importance of physics research, both fundamental and applied, to the success of a high-tech society is generally acknowledged, the societal role of physics and its collaborative interface with industry were also considered.

A specific motivation was to get an overall view of the impact of Academy funding and the performance of different funding instruments. Besides general research grants, this concerned graduate schools (whose funding is administered and partly covered by the Academy), Centre of

Excellence Programmes (which are funded primarily by the Academy), and the Finland Distinguished Professor Programme FiDiPro. An international evaluation covering the whole Finnish physics research field was seen also as beneficial to the strategic planning of universities and as complementing the evaluations the universities themselves make. The evaluation is also timely with respect to the new overall review of the state and quality of scientific research in Finland, which was released in October 2012.

1.3 Organisation

The Research Council for Natural Sciences and Engineering appointed a steering group to supervise the evaluation process. The first meeting of the steering group took place in November 2011, chaired by Professor Erkki Oja, who is also Chair of the Research Council. The other members were: Professor Lassi Päivärinta (University of Helsinki), Vice Chair and also a member of the Research Council, Principal Scientist Asta Kärkkäinen (Nokia Ltd), Director Janne Ignatius (CSC – IT Center for Science), and Managing Director Veli-Pekka Leppänen (Nanocomp Ltd).

The steering group appointed Dr Mikko Lensu as the scientific coordinator of the evaluation. On behalf of the Natural Sciences and Engineering Research Unit of the Academy, the process was managed by a team composed of Senior Science Adviser Pentti Pulkkinen, Science Adviser Samuli Hemming and Project Officer Henriikka Kekäläinen. With the help of the team, the steering group convened an international expert panel, which was appointed by the President of the Academy, to carry out the evaluation.

1.4 Implementation

The steering group decided that the evaluation would span the five-year period 1 January 2007–31 December 2011 and identified the research to be covered by a set of key criteria. It was outlined that the units should belong to physics departments or have otherwise clearly physics-oriented research profiles and that the units must not have been included in recent evaluations of the Academy of Finland or planned to be included in some other evaluations in the near future. This then included all physics research conducted in physics or applied physics departments at Finnish universities, together with certain other units with clear physics-related research profiles. Space physics and atmospheric physics, usually counted under geosciences, were also included, as these fields were not covered by the previous Academy evaluation of geosciences. After negotiations with the universities, and taking into account what is possible to accomplish by the evaluation panel within five days, 30 units were selected to be evaluated.

The steering group accepted an evaluation form prepared by the Academy team and the coordinator (Appendix D). The two-part form was sent to the units in December 2011, to be returned after the six first weeks of 2012. Part I contained quantifiable data on research profile, resources and research output. As concerns research profile, it was decided that the form should follow the official research field classification presently used by the Academy, which divides physics into six subfields. However, in this report, the evaluation panel chose to divide the field somewhat differently so as to better cover the geo- and materials sciences. Part II of the form was reserved for a self-assessment on research strategy, publications, collaboration, infrastructure, administrative and educational load, societal impact and funding. The units were also asked to assess their future prospects, evaluate themselves in relation to leading competitors and provide a SWOT analysis.

The objective of the evaluation, as defined to the evaluation panel in the Terms of Reference (Appendix C), was to evaluate the scientific level of Finnish physics research in international comparison. The panel was asked to look at the research quality from three different viewpoints: the field as a whole, the different subfields, and the research unit level. The panel was also asked to assess the topicality and comprehensiveness of the distribution of physics subfields at Finnish universities, the sufficiency of available resources and their distribution across subfields and the adequacy of present or planned research infrastructures on a local, nationwide and international level. In addition, the panel could consider issues such as research networks, collaboration, mobility, education and research policies, impact on science and society, or any other issue the panel considered important.

All evaluated units were interviewed by the panel during 7–11 May 2012. The interviews typically took 1.5–2 hours, depending on the size of the unit, and they consisted of a short presentation by the unit followed by a discussion between panel members and unit representatives. At least three panel members were present during each session.

1.5 Some key figures

The total funding for the 30 evaluated units was EUR 450 million over the five-year evaluation period of which 38 per cent was core funding and 62 per cent external funding. Academy, Tekes and EU funding accounted for respectively 22, 11 and 9 per cent of the total funding. The total manpower of all research staff was 975 FTEs (full-time equivalents), 444 doctoral-level researchers and 102 professors. Men accounted for 86 per cent of doctoral-level researchers. During the five-year period the funding increased by 57 per cent and doctoral-level staff by 26 per cent, mostly due to the 58 per cent increase in the number of postdoctoral researchers. During the same period, the share of Academy funding increased from 16 to 27 per cent. The units produced 7,900 journal articles during the evaluation period, or 3.5 articles per doctoral-level researcher per year. The number of MSc and PhD degrees was around 200 and 100 per year, respectively.

1.6 Notes on terminology and style

(i) This report presents the perceptions of the evaluation panel. In this introductory section and in the Appendices, the panel has been assisted by the editor and the Academy of Finland; otherwise the panel as a whole is responsible for the text. However, various parts of the report were initially contributed by different panel members, resulting in variations in style and emphasis that may be visible in the report.

(ii) The host organisations of the units are abbreviated as follows:

AU	Aalto University
FMI	Finnish Meteorological Institute
HIP	Helsinki Institute of Physics
LUT	Lappeenranta University of Technology
TUT	Tampere University of Technology
UEF	University of Eastern Finland
UH	University of Helsinki

UJ	University of Jyväskylä
UO	University of Oulu
UT	University of Turku
ÅA	Åbo Akademi University

(iii) The report also includes the following abbreviations:

ALICE	A Large Ion Collider Experiment
CERN	European Organisation for Nuclear Research
CoE	Centre of Excellence
CMS	Compact Muon Solenoid
CSC	IT Center for Science
ESA	European Space Agency
ESRF	European Synchrotron Radiation Facility
ESFRI	European Strategy Forum on Research Infrastructures
ERC	European Research Council
FAIR	Facility for Antiproton and Ion Research
FiDiPro	Finland Distinguished Professor Programme
FIRI	(Academy of Finland call for) Finnish Research Infrastructures
FTE	Full-time equivalent
HEP	High-energy physics
LAGUNA	Large Apparatus studying Grand Unification and Neutrino Astrophysics
LHC	Large Hadron Collider
NMR	Nuclear magnetic resonance
QCD	Quantum chromodynamics
SME	Small and medium-sized enterprises
SMEAR	Station for Measuring Forest Ecosystem-Atmosphere Relations
Tekes	Finnish Funding Agency for Technology and Innovation
TOTEM	TOTal Elastic and diffractive cross section Measurement
VTT	Technical Research Centre of Finland

2 OVERALL ASSESSMENT OF THE QUALITY OF PHYSICS RESEARCH IN FINLAND

2.1 Quality and scope

Physics research in Finland is pursued in ten universities by both large and small groups working in different fields. The general quality of the work is very good and meets high international standards. There are also several excellent groups performing at the same level as the corresponding best groups internationally. It will be important to support and maintain the best groups at the same time as certain other activities are redirected or are phased out.

Several of the biggest groups or activities receive a correspondingly large part of the available funding in Finland. In some instances, there is the impression that these groups continue to thrive from pure inertia long after their main research field has ceased to be at the frontier of modern physics. Funding agencies should seek to identify fields with new developments and give them the possibility to grow, although this would mean reducing the support to certain other sectors. This will in particular be necessary in the coming years as the general funding situation is expected to become more difficult.

Present-day Finnish physics research covers essentially all current international trends to varying degrees. New important fields of investigation will continue to come up while interest in certain others will wane. This will require a flexible and dynamic research establishment that can react to such developments. At the national level, Finland should avoid building and supporting almost identical activities at different institutions, as the country is too small for that. Some activities must necessarily overlap in order to offer the best teaching and training, but this should in general be avoided. Overlaps in research due to the tradition of offering teaching in the two official languages, as in Turku, should be remedied by closer integration such as in Helsinki.

Finnish physics has a base of students with the best education in the world. But when they start their research career, they often end up in groups where their future prospects look less promising due to a lack of clear tenure-track positions. To some extent, this has been remedied by the Centres of Excellence, which in many cases have groups that are headed by younger people. Most of them function very well and should be further developed in the coming years.

At some universities, there is a disconnection between the departments hosting the groups, and the groups themselves as regards strategic planning and establishing research profiles. The resulting autonomy for the groups in setting their own direction has some advantages, but the result can also be a less-than-optimal utilisation of funding resources and new positions. The panel sees the need for those departments to get more involved with the activities of the groups. Such an initiative could also be taken to pursue more ambitious goals where this is warranted.

Conclusions and recommendations:

1. More tenure-track positions should be made available. These should come with ample start-up funding to allow for new directions of research to be pursued.
2. Each physics department should aim at establishing at least one Centre of Excellence or EU-funded project at their institution.

2.2 Funding

The overall funding situation for physics at Finnish universities is quite good, compared to many other countries. Most groups get their largest proportion of external funding from the Academy of Finland. In particular, this is true for the groups within Centres of Excellence. While many groups can be regarded as well funded, being highly successful in obtaining competitive funding, some groups struggle to get sufficient support from their universities and from external funding sources. At the beginning of the five-year evaluation period, the proportion of core funding was about 50 per cent, and it decreased to about 37 per cent by the end of the period. The external funding has increased correspondingly. This means that there is a clear trend towards more competitive funding in recent years. Although the panel supports a significant competition-driven funding proportion, it is of some concern that this trend has brought the core funding to a critical limit where long-term research goals are impacted negatively. To this adds the constant burden of applying for and handling funds from many scattered sources. Therefore, the current proportion of core funding should at the very least be maintained, if not increased, to guarantee efficient and sustained research.

It can be assumed that the role of EU funding at Finnish universities is likely to increase in the coming years. This will require a sustained effort and often a large administrative burden in connection with reports and applications. Today, there seems to be very little administrative help for this often very demanding work in essentially all of the institutions the panel visited. Much of the time and effort spent by the scientific personnel on this activity could be better used on purely scientific matters. In many other countries, this help comes from the university central administration or from the physics departments to which the research groups belong. This administrative link seems to be missing at most of the institutions in Finland today.

One problem with the current funding scheme of the Academy of Finland is related to the success rate of individual grants. In recent years, the success rate has dropped to 17 per cent and below. Such a low rate means that even for good proposals, the chances to be funded are rather marginal. There is no good solution for this problem other than increasing the amount of funding for individual grants.

Conclusions and recommendations:

1. There is widespread concern about sustained funding and the fact that the balance between sustained, long-term core funding and short-term competitive funding has shifted too much towards short-term funding with the implication of abrupt discontinuity in funding.
2. Areas already at the cutting edge of international competition should receive sustained funding, but new efforts in cutting-edge frontier research should be supported by seed-funding as well.
3. The success rate for individual grant proposals should be increased.
4. Proper administrative support for funding applications such as for EU projects should be provided at the university level.

2.3 Recruitment

The nature and efficacy of recruitment procedures for new academic staff are crucial to the maintenance and success of high-quality research and teaching. This is especially so for physics, a discipline that has long been characterised by global competition, both at a fundamental and applied level. Being able to attract and recruit internationally leading academics is not only important for achieving a good standing in the international community but especially for training the next generations of research leaders and for creating the vision to develop new research directions. All this will also foster economic development in high-tech areas.

Most Finnish universities have in place high-quality recruitment procedures essentially in keeping with the typical best practices at European or international level and with advertisements in high-profile international journals. An even wider dissemination of calls for positions in well-established and web-based academic job recruitment services could, however, still further increase international visibility and enlarge the recruitment basis. This would potentially enable higher-quality recruitments.

There is a concern about recruiting at the international level in cases where universities seek to offer a specialised service (e.g. teaching in Swedish). Such special requirements may unduly limit the recruitment basis. More generally, although Finnish universities generally have a good level of international interaction through research and secondments of PhD students, the level of internationalisation of academic staff recruitment requires strategic attention at national level. This could happen, for example, with dedicated programmes providing additional incentives for foreign academics at all career levels to relocate to Finland. Another example would be programmes designed to encourage Finnish nationals to return to faculty positions in their homeland after receiving postdoctoral and other research experience abroad.

Recruitment of PhD students in the evaluated units seems to be of very high quality and well aligned with the practices of other European countries.

Conclusions and recommendations:

1. An effort should be made to increase, at all levels, the number of faculty members with research experience gained outside Finland.

2.4 PhD training

As the culmination of the rigorous classical education in Finland, current doctoral training is excellent. As a result, graduates are in high demand and typically go onto research jobs in academia and industry, often obtaining postdoctoral positions at leading international research institutions. The time it takes to obtain a PhD in physics ranges from three to seven years, and is typically about five years. Most of this time is spent doing research, with about 5 per cent spent on teaching. This amounts to about 80 hours per year or 4–5 hours per week, which is very reasonable. While teaching is not always required of graduate students, many value the experience. Ample opportunity to travel abroad to conferences and for extended stays with collaborators greatly enriches the graduate training experience.

One source of concern for both the faculty around the country as well as the evaluation panel is the imminent changes in graduate education. Currently, national doctoral training programmes in specialised areas of physics pool the resources and expertise from various institutions to train graduate students in these areas. This strategy works well since there are often not enough faculty and resources at one university to train students in all subareas in question.

Funding for graduate students does not primarily come from the university, but rather from external sources such as national training programmes and Tekes. Although there is no clear need for changing this system, the Graduate School Working Group recommended in 2011 that universities adopt overall responsibility for doctoral training as is done in other countries such as the US. It is anticipated that most graduate student funding will now go through universities rather than through national training programmes. The concern is that this will eviscerate the national training programmes by depriving them of the breadth of expertise and experience that comes from bringing together people from institutions around the country. It is not clear to the panel that these recommended changes will improve graduate training, and it is hoped that doctoral training will be maintained at the same high level that currently exists.

Graduate students are an integral and essential part of the research done around Finland. In addition, graduates are a key part of the workforce in high-tech industries. So, another source of concern is the decreasing number of domestic graduate students in physics. This downward trend is due to the reduced interest in the natural sciences among young people and deliberate efforts to decrease the number of undergraduate physics majors in an attempt to increase the teacher-student ratio. To increase or maintain the number of doctoral students, efforts are being made at some institutions to make degree programmes more attractive to both domestic and international students.

Conclusions and recommendations:

1. Every effort should be made to ensure that current excellence in doctoral training be maintained as universities adopt overall responsibility for graduate education.
2. To maintain and increase the number of graduate students, more widespread efforts should be made to recruit international students.
3. PhD training in physics should be made more attractive to the most able students by providing a certain number of funded individual “national” PhD fellowships. This would allow these students to select their fields of specialisation and join the groups most suited to their interests.

2.5 Relevance to society

Physics is a widely diverse field overarching important societal problems from cosmology to nanotechnology, from industrial applications to environmental and life sciences. Generally speaking, Finland has reached a level of high international esteem in several physics branches with strong impact on industrial, environmental and basic research. While Finland cannot cover all aspects with similar depth, Finnish research and education in physics has been excellent in defining niches of important and challenging problems – and concentrating on these. Physics research and training in Finland are highly relevant and clearly match societal needs. Students graduating in physics from Finnish universities normally immediately find employment in industry or research. They are also much sought after by international competitors for their excellent training. Research and development is often done in collaboration with industry and national cooperation is generally well developed. The direct relevance to society can also be seen in the number of successful small start-up companies that have grown out of excellent basic research in Finland.

Physics departments at Finnish universities very often have developed strong international collaboration and are leading or actively participating in international research projects. Overall, there is a good balance between basic and applied research, but this also varies from unit to unit.

Conclusions and recommendations:

1. To turn around the declining number of physics students in Finland, efforts should be made by each university in terms of outreach programmes. These efforts should be supported by the Ministry of Science, Education and Culture.

2.6 Internationalisation

The international visibility of the evaluated units is in general high, although not at the same level for all. For the research in particle and space physics, there is a long standing tradition to perform experimental work in large international collaborations and in laboratories outside Finland, in particular at CERN. Indeed, researchers involved in particle physics, in cosmology with the project Planck and in space physics internationally play an over-proportional role as compared to the Finnish population. For nuclear physics, the research programme is partly conducted outside Finland, mostly at CERN, while the main focus is the research at the University of Jyväskylä. The Accelerator Laboratory at Jyväskylä is a well-organised and truly international facility in Finland and also the only one of its kind in the Nordic countries. It attracts users from different countries and is recognised by the EU as a European Large Scale Facility.

In materials science, nanoscience, low-temperature physics, computational and theoretical physics, international collaborations are extensive and well organised with involvement in several Europe-wide projects. The researchers in optics and photonics have in general well-established collaborations in Europe and also with institutions in the US and Asia. Internationalisation is a key issue also in applied physics and multidisciplinary sciences such as medical physics, biophysics, organic electronics and aerosol physics. Especially the division of atmospheric physics at the University of Helsinki is coordinating a large number of affiliated international projects with participants from many (of the order of a hundred) different countries.

The international collaborations facilitate the mobility of academic personnel and PhD students and help attract foreign visitors. The research is promoted internationally also by recruiting international postdoctoral researchers and sending a large proportion of physics PhDs abroad to gain experience and increase the international contacts that are particularly useful to launch projects based on new ideas. EU funding facilitates these exchanges to a large extent. In some units, the strategy for internationalisation is less developed than in others. This appears to be due partly to the unit's location and to some degree to the difficulty of maintaining and upgrading the infrastructures to make them attractive for foreign nationals. In general, all units make efforts to guarantee to all local students visits abroad at least at the level of participation in conferences and international schools. Once Finnish students complete their PhD training, many go abroad for postdoctoral positions at leading institutions. These are often places that already have Finns, so it would be beneficial to expand the network by having expatriate Finns working abroad at a variety of research institutions.

Conclusions and recommendations:

1. The use of Finnish research infrastructures by foreign scientists should be facilitated. Finland should attract users and visitors bringing also resources useful to make the research even more efficient.
2. A foreign visitor programme should be established that works in both directions similar to the one at the German Alexander von Humboldt Foundation, which allows creating an international contact network over time.

2.7 Infrastructure

Research infrastructures are a very important and often essential component of physics research today. There are three different levels of infrastructures: local laboratory equipment, national and international large-scale infrastructures maintained in Finland, and international infrastructures outside Finland used by Finnish groups. Overall, the current situation in Finland is quite good at all three levels, but there are vast differences depending on the university and the particular groups. While some universities such as Aalto, Helsinki, Jyväskylä and Tampere seem to have excellent research infrastructures in general, there are some universities such as Turku, Åbo and Lappeenranta where at least part of the laboratory equipment is outdated to an extent that clearly limits the quality of research. At these universities, the funds for new equipment seem rather marginal for some groups and an overall plan for improving the situation is missing. Of particular concern is that, at these universities, even the start-up funds offered for new appointees are rather limited. Obviously, this makes it very difficult for the groups to compete for the best appointees.

Some university groups in Finland have developed outstanding and in various ways unique large-scale infrastructures that are internationally accessible and currently maintained by these groups. A problem is that the funding for these infrastructures often comes from scattered sources. Large-scale infrastructures are very expensive and time-consuming to build. It is important that plans for their use, maintaining and development are embedded in the long-term strategic planning involving universities, the physics community, funding agencies and the Ministry of Education, Science and Culture. In 2009, an international panel evaluated all large-scale research infrastructures in Finland and identified 24 national-level research infrastructures, among which are several physics projects. The panel also established a corresponding roadmap. This exercise was a very good first step in identifying, preserving and further developing such infrastructures. All large-scale infrastructures maintained by physics groups recognised by this evaluation are excellent and will be an important component for future physics research in Finland.

In addition, there are some infrastructures in the planning that can only be built via national or international efforts. One example is the Pyhäsalmi mine underground laboratory. This mine is the deepest mine in Europe and a very interesting option for a unique underground site, especially as it is a candidate site for the pan-European neutrino observatory LAGUNA. Finnish groups are also involved in a number of international infrastructures such as CERN, ESRF and FAIR. Overall, the contributions made by these groups are very good.

Conclusions and recommendations:

1. An infrastructure call for laboratory equipment is needed to help replace outdated apparatuses in some units and provide an opportunity to obtain infrastructure for new appointees.
2. A long-term funding scheme for large international infrastructures in Finland should be established.
3. Raising the financial contribution to international infrastructures such as CERN and FAIR could certainly enhance the visibility and role of groups involved in such experiments.
4. In case the LAGUNA observatory should be established at the Pyhäsalmi mine, it should be considered whether to make the mine a general underground site for national and international experiments.
5. Some Finnish groups would also benefit greatly from membership in the XFEL (X-ray Free Electron Laser) in Hamburg or other FEL facilities.

2.8 Recommendations to the Academy of Finland

Generally, the researchers in the evaluated units seem to be quite happy with the funding provided by the Academy of Finland. During the time period covered by this evaluation the funding strategy of the Academy certainly strengthened the quality of research in physics in Finland. In particular, the substantial long-term funding given to Centres of Excellence (CoE) created top-level research competitive at an international level. The proportion of funding put into CoEs has increased in recent years, clearly reflecting the intention of the Academy.

However, this shift in funding, among other influences, has created a problem that needs to be addressed by the Academy: the very low success rate for individual project funding applications. In recent years, the success rate has fallen below 17 per cent, which does not allow for a reasonable individual funding programme. At first glance, it could be argued that such a low success rate means that the programme is very competitive and only the very best get funded. However, the funding decisions contain a significant statistical element and as a consequence the applicants change their attitude. A strong funding scheme for individual proposals is very important in order to maintain the strength of individual groups also outside CoEs and in order not to miss new individual ideas that sometimes lead to unexpected breakthroughs. The research carried out by CoEs covers mainly physics research in already established fields. However, at any given time there may emerge bright ideas that will develop into new hot topics. The panel therefore recommends that the Academy consider readjusting its funding scheme to obtain a success rate of no less than 30 per cent.

In addition, there appears to be a lack of flexibility in funding from the Academy, making it difficult to recruit young researchers in an optimal way. In other words, new appointments have to be made soon after new project funding has been granted, while if an exceptionally promising scientist asks for a position, typically there are no reserve funds to make an offer right away. One of the biggest problems with Academy funding is related to difficulties in extending the end of the funding period, which is not possible except for special reasons. The Academy should consider allowing no-cost extensions that would allow funds to be spent past the initially accepted end date of the grant.

Several university groups in Finland have established large-scale infrastructures, some of which have been recognised as national infrastructures, but have often great difficulties in maintaining them. Secure long-term funding can enormously help free the involved groups from the burden of gathering the money for such infrastructures from scattered sources. The panel feels that the Academy is the ideal institution to identify such infrastructures and provide them with long-term funding.

Traditionally, the Academy has supported basic research to a large extent. This is very important since research on a fundamental level is the solid ground on which later applications can be developed. The panel recommends that the Academy maintain this funding policy and support basic research without the requirement for industrial partners or immediate societal impact.

Although the networking and visiting programmes certainly differ somewhat between units, there seems to be a general lack of visits of established scientists and postdoctoral researchers from abroad. Such visits and corresponding return visits are crucial to establish a non-formal, individual contact-based, international network that can last a scientific lifetime. The Finland Distinguished Professor Programme is certainly one way to address this problem. However, the panel recommends that the Academy consider establishing an additional programme similar to the one hosted by the German Alexander von Humboldt foundation, which stimulates visits in both directions and strengthens long-term relations.

It seems that start-up funding for young faculty members is rather limited at some universities. Given the low success rate of individual grants, the Academy should consider giving applications by starting professors higher priority in this programme.

2.9 Recommendations to the Ministry of Education, Science and Culture

Basic research in a broad variety of subdisciplines in physics is essential for the sustained and long-term prosperity of industry in any country, but especially in those without major natural resources. In particular, this is true for a country like Finland with a substantial high-tech industry. Also the promotion of a profound natural science background, starting at a young age at schools nationwide, is very important for a technology-driven society.

Broad support for physics research and education should have a high priority in Finnish policies, and the Ministry of Education, Science and Culture should seek to provide the best possible conditions for physical science in Finland. To fulfil their goals in research and education, the universities need sufficient funding. In recent years, there has been a clear shift towards more competitive short-term funding. The panel sees this development critical, since a system that relies mostly on competitive funding is short-term-oriented and misses long-term aspects. The Ministry should provide substantial core funding so that research units can maintain their staff levels and infrastructures. Equally important is that universities and research units are freed from unnecessarily detailed regulations and quality assessments. The Ministry should not second opinions that state that science is merely an intellectual assembly line, as this leads to pseudo production, inefficient research and a lack of creativity. Obviously, science is not assembly line production and scientists are not cows that can be milked. Scientists need a stimulating environment and supporting boundary conditions to achieve their goals in the most efficient and best way.

However, ample freedom as a necessary condition should be accompanied by long-term strategic planning by the Ministry. Ideally, this should be obtained in a close dialogue with universities and the corresponding research groups. The panel recommends that the Ministry demand long-term strategic plans from all universities including research profiles, appointment plans, infrastructure needs and organisational and educational aspects. If approved, these strategic plans should form the basis of long-term funding for these universities.

Making good appointments is one of the most important strategic tasks of a university. Currently, the vast majority of faculty members in physics departments at Finnish universities are from Finland. This shows that an appointment at a university in Finland is currently not very attractive to foreign scientists. There may be a number of reasons for this. Without speculating, the panel recommends that the Ministry consider implementing a programme to attract high-level scientists from outside Finland to further promote cutting-edge research and teaching in physics in Finland. The Finland Distinguished Professor Programme jointly administered and funded by the Academy of Finland and Tekes is certainly a very good step in this direction, but it is aimed only at medium- and long-term visits and collaboration, not at permanent employment.

Some of the evaluated units appear to be of subcritical size. The Ministry of Education, Science and Culture and the involved universities should consider merging some of these units to create competitive and sustainable groups, and to phase out other subcritical sized units depending on their prospects. A special situation is apparent in Turku due to the tradition of offering teaching in the two official languages of Finland. As a consequence, the University of Turku and Åbo Akademi University both have rather small physics departments and include some groups of subcritical size with only moderate strength in research quality and output. They would greatly benefit from close collaboration in teaching and research. In the long run, the Ministry should consider whether a merger is possible, while still offering teaching in the official two languages.

In modern physics, large-scale research infrastructures are often necessary tools. Finland has some excellent examples of such infrastructures that should be maintained and further developed. For university groups, it is often very difficult to maintain these infrastructures, especially if an increasing proportion of support has to come from competitive funding. The panel recommends that the Ministry identify these infrastructures and, together with the Academy of Finland, develop plans for a sustained long-term support of such facilities. The recognition of 24 national research infrastructures in Finland in 2009 and the corresponding roadmap are certainly very good first steps in this direction and they should be carried even further.

In addition, if possible, the Ministry should consider stepping up the Finnish share in some particularly important international infrastructures to provide even more opportunities for Finnish groups and to enhance international visibility.

3 EVALUATION OF THE MAJOR SUBDISCIPLINES IN FINLAND

3.1 Atmospheric physics

From the very beginning, atmospheric physics in Finland was concentrated on microscopic aspects of aerosol formation and characterisation, and on the role these tiny particles play in the atmosphere in terms of the formation and development of clouds and precipitation. Aerosols interact with radiation and are, as cloud condensation nuclei, the necessary prerequisite for the formation of clouds under natural conditions. These processes were little understood in the past and even today, leading to the biggest uncertainties in climate simulations. Finnish research has initiated and drives the progress in this field with theoretical, laboratory and field studies. Concentrating on a highly important but extremely challenging topic was obviously the right strategy in view of the limited resources. During recent decades, Finland became the world leader in these fields. Today, Finnish research institutions are a vital part of the international atmospheric physics community, having established extensive bi- and multilateral collaboration with other centres and in international research programmes, giving access to the wider field of Earth system research.

The centre of atmospheric physics in Finland is found in Helsinki. Here, the synergies evolving from co-location on one campus of the Division of Atmospheric Sciences at the Department of Physics, University of Helsinki, and the Finnish Meteorological Institute (FMI) allowed for the creation of a world-renowned centre of excellence. The centre's theoretical, observational and numerical simulation research activities range from the initial formation and growth of particles to their interaction with clouds and, preferentially in international cooperation, resultant effects on weather and climate at the regional to global scale. Helsinki is also the only place in Finland offering university-level education in atmospheric physics or meteorology.

Two other Finnish universities are involved in atmospheric physics on a quite smaller scale. At the University of Eastern Finland, Kuopio, high-end measurements of aerosols and cloud microphysics are combined with numerical modelling at microscopic to cloud scale. The Aerosol Physics Group at Tampere University of Technology mainly concentrates on applied research including development of new instruments and synthesis of aerosols.

The units related to atmospheric physics in Finland, including the FMI, cooperate very closely. This cooperation is mainly coordinated by a number of Centres of Excellence and by sharing observational platforms such as the four SMEAR stations (Station for Measuring Forest Ecosystem-Atmosphere Relations) scattered across Finland, which provide comprehensive data on aerosol precursor gases, new particle formation and evolution of particles and cloud droplets. Academic positions are shared between the different units (including the FMI) in a significant number, facilitating exchange of expertise and mobility between the institutions. The dominance of Helsinki may be seen as twofold: It is a clear benefit to concentrate limited capacities in one place as it allows for more expensive facilities to be supported and provides a wide range of expertise at one place leading to welcome synergies. However, there is also a risk of taking capacities from the smaller units making them subcritical in the long run. The panel suggests taking this risk seriously and actively supporting the aerosol physics groups outside Helsinki.

3.2 Biological physics

Internationally, biological physics is a rapidly growing field of physics that is attracting an increasing number of young researchers. It involves using experimental and theoretical techniques to study problems that are relevant to biology and medicine. Traditionally, biology has focused on identifying and classifying different components of biology. Physicists can bring quantitative tools to help us understand how biological mechanisms work, spanning the range from the single molecule level to systems biology, ecology and population dynamics. Biology is a vast field and so are the possibilities for where biophysicists can play an important role.

There is not much research in biological or biomedical physics in Finland. Groups at four universities have an experimental or modelling approach to biological and medical problems as well as to bioengineering. Only one unit offers degrees in biophysics. The problems that are studied differ widely but are very interesting. These include simulations of receptor-ligand interactions in cell membranes, X-ray studies of developing trees and teeth, biomaterials (e.g. biofilms, cellulose and bionanocomposites) with applications in biofuels, the neuroscience of vision, and biomedical applications of ultrasound. There is some effort in medical physics research especially with regard to radiation therapy for cancer. The panel saw some effort in bioengineering including initial steps towards a virtual reality contact lens and using functionalised organic molecules with semiconductors to mimic light harvesting as in photosynthesis. However, as the panel focused on physics research, other bioengineering efforts may have been missed. Such diversity means that biophysics research is not at a level to compete for Centre of Excellence status, but must be supported through individual research grants that are very competitive and difficult to obtain. The current transition to a university tenure-track system without a tradition of providing substantial start-up funds and grant funding earmarked for young researchers means that it is challenging for assistant professors to move in new research directions such as biological physics.

Given the strength of Finnish biological and biomedical research as well as the rapid growth of biological and biomedical physics around the world, serious consideration should be given to having more biological physics research in Finland. This could strengthen current national efforts in biology and medicine as represented by several Centres of Excellence. Training PhDs in biophysics would also provide technical expertise to help foster greater economic diversity with the establishment of biotechnological and pharmaceutical companies.

3.3 Computational physics

Computational physics applies advanced theoretical and computational methods to condensed matter, materials and biological physics. The topics covered range from those that are of interest to basic research to those that have important practical applications. In Finland, computational research covers the electronic properties of materials, surfaces and interfaces at the nanoscale, quantum many-body physics, quantum computing and devices, multi-scale statistical physics, complex systems and materials, spectroscopies and lipid-protein interactions. This is often done in close collaboration with experimental groups. In addition, some experimental groups do their own modelling to elucidate their experimental findings.

Computational physics is exceptionally strong in the Centre for Excellence in Computational Nanoscience at Aalto University and in a unit at the Tampere University of Technology (TUT). Prestigious accolades, publications in high-profile journals and extensive collaborations at local, national and international levels are evidence of the impact that these efforts have.

Both research funding and infrastructures are good. In addition to the national supercomputing facilities at CSC the local in-house infrastructures are state-of-art, though the small unit at TUT is constantly challenged to keep its facilities at the cutting edge.

There is some concern about the training of young researchers due to both the decreasing number of physics majors and the transition from funding graduate students through national doctoral training programmes to paying students through universities. This should be monitored to ensure that both the quantity and quality of doctoral graduates does not diminish.

3.4 Condensed matter and materials physics

Condensed matter physics and materials physics are both very large, diverse and interrelated fields of physics. Given the size of a country like Finland, it is absolutely clear that not every aspect of these research areas can be covered. In the last decade, internationally the most visible trends have been nanoscale physics and the physics of strongly correlated systems. Both of these topics are also represented by Finnish groups. In particular, nanophysics is pursued by many groups and can be considered as a very strong research field in Finland. The activities in terms of strongly correlated (fermionic) systems are present in some places, but appear more scattered compared to nanophysics. One highlight in terms of strongly correlated fermionic systems is the research into superfluid helium-3 at ultra-low temperatures. Overall, the research level in condensed matter physics and materials physics is rather high, with some groups clearly demonstrating international leadership.

Almost every university in Finland has some research activity in condensed matter physics or materials physics. However, there is some variation in the magnitude and the quality of these activities. Whereas some areas such as low-temperature physics and nanoscience involve cutting-edge research with state-of-the-art infrastructure, other areas clearly seem to be somewhat less competitive. In nanophysics, there is an emphasis on carbon nanotubes and graphene. Particularly interesting is that some groups in Finland have created their own niche in this fast moving field and make unique and excellent contributions. Also, the facilities for micro- and nanostructuring at several universities are on a very high level, providing an opportunity for creating complex micro-fabricated devices, both for fundamental research and applications. Among those devices are quantum dots, single-electron transistors, optoelectronic components, SQUIDs (superconducting quantum interference devices) and voltage standards. Low-temperature physics research also has a long tradition in Finland, with the O.V. Lounasmaa Laboratory playing a leading role. Some of the facilities operated at this laboratory are matchless worldwide and allow for investigating various forms of matter under unique conditions. The materials physics section, in particular, benefits from both good to excellent (clearly it is a difference between these groups) spectroscopy (NMR, X-ray, electron and positron spectroscopy) and excellent contributions from computational physics and synthesis facilities (Tampere). Again, there is no way to cover the full spectrum of international materials science in Finland, but some of the existing activities are excellent and have an impact on an international level.

On the other hand, some smaller groups (Turku, Åbo and Lappeenranta) seem to be somewhat more isolated both nationally and internationally. They do not show the level of activity that is necessary to attract many good students and be visible on an international scale. These groups need to be strengthened by stronger collaborations with other national and international groups and most importantly by a thoughtful appointment policy at their universities. The situation should be analysed carefully and activities of subcritical size should be reconsidered. A long-term structural plan for condensed matter physics and materials physics should be generated at these universities to create more competitive units.

A large proportion of the projects in Finland involve fundamental rather than applied research. Nevertheless, there is technical development alongside with many of those activities and a substantial number of small companies have been created during the period under evaluation as spin-offs of these activities. The conversion of results or by-products of the research in fundamental physics into real products seems to be comparatively easy in Finland on an international level. In addition, there are a number of purely applied projects that have obtained funding from Tekes and directly from industry. Overall, it appears that the balance of fundamental research and applied research in the area of condensed matter physics and materials physics is excellent and should be maintained.

3.5 High-energy physics

During the last 10–20 years, high-energy physics (HEP) has increasingly come to be identified with problems that are central in modern cosmology. In particular, this is evident in the search for a physical understanding of the very early universe. This is a development seen in all other countries and has also characterised the research in Finland in the same period. It is the motivation for most of the experimental work and the goal of theoretical high-energy physics in Finland.

The Standard Model for elementary particles now gives a detailed understanding of most phenomena seen around us. However, there are still unanswered questions that hopefully can be answered in the near future with the discovery of higher symmetries and perhaps also extra dimensions. This will have direct relevance for the understanding of the physics just after the Big Bang and the subsequent evolution of the universe. The Finnish activity in this respect is of very high quality and has been clearly visible internationally over a long period. In particular, the effort to develop modern cosmology from particle physics has been very successful in Finland, which was one of the first countries where this research was initiated.

Most of the research in high-energy physics is being done at the University of Helsinki and the embedded Helsinki Institute of Physics (HIP). This institute was founded and is partially funded by several other universities and has served to unify and strengthen the activity within this field. In particular, it has benefited the HEP group at the University of Jyväskylä, which is significantly smaller than the University of Helsinki both in personnel and activity.

Experimental work in HEP is mainly done at CERN and is concentrated around the CMS experiment at the LHC accelerator. This involves both physics analysis, detector operations and more technical contributions. Today, this is the biggest general-purpose experiment in Finland and has already produced a large number of publications and doctoral students. There are high expectations for new, fundamental results in connection with the Higgs sector and possibly also in supersymmetry in the coming years. In addition, there is a smaller involvement in the TOTEM experiment at CERN, which investigates less fundamental questions at these high energies. At LHC, there is also participation in the ALICE experiment in collision of high-energy nuclear ions. These collisions can produce the quark-gluon plasma described by QCD. This activity is concentrated at the University of Jyväskylä. Presently, the activity is located in the particle physics group, but in many ways it belongs more naturally to the nuclear physics group as in many other countries.

At Lappeenranta University of Technology, there is also a surprisingly successful contribution to the CMS experiment at CERN in terms of several thousand electronic boards for the internal trigger built and tested there. This is especially noteworthy in light of the minimal size and resources of this group.

In the next few years, it will be decided if the Pyhäsalmi mine in Finland will be used for the LAGUNA consortium to build up a next-generation neutrino detector based on a beam directed from CERN. Should this be approved, it would have a great impact on HEP in Finland, both from an experimental and a theoretical point of view. This will obviously also change the whole funding situation. In spite of this, the panel sees this as a very new and positive avenue for future HEP activities both in Finland and on a greater scale.

Theoretical HEP is very active in terms of staff, students and visitors. It is well organised with teaching and research of the highest quality. The activity is now concentrated around experimental work going on at LHC and also around cosmology based on new data from the Planck satellite. In the last five years, theoretical groups have produced a large number of students and several of their PhDs have later made careers abroad.

Both the experimental and theoretical HEP activities in the Department of Physics at the University of Helsinki have joined in an application to become a Centre of Excellence. Should this be approved, it would strengthen the research effort in Helsinki and increase the visibility of all HEP research in Finland. In addition, a closer collaboration between theory and experimentation will be crucial in the coming years when the direction of the theoretical development will be strongly influenced by experimental results coming from the LHC accelerator.

The group at the University of Jyväskylä is much smaller and less visible. Here, the research effort is more fragmented, mainly concentrated on four separate directions corresponding to the four leading staff members. To some extent, neutrino physics and unified theories for the electroweak sector could provide a common interest. Since the heavy-ion research is concentrated around the ALICE experiment, the panel would encourage moving this activity under the umbrella of the nuclear physics group, which has a longer tradition in the field. The HEP activity at the University of Jyväskylä would then get a more well-defined research profile.

3.6 Nuclear physics

The research activity in nuclear physics in Finland is motivated by the challenge of understanding the sub-atomic world governed by the interplay of nuclear forces. This enterprise is approached by novel experimental methods using ion-induced reactions allowing researchers to probe the properties of unstable nuclei far from stability, where the discovery potential is the highest. An improved knowledge of unstable nuclei is also imperative for our understanding of the formation of elements in nucleosynthesis processes.

In Finland, nuclear physics is carried out to a large extent at the University of Jyväskylä, where there is an important facility in an international context. In addition, a small group is active at Åbo Akademi University, which uses external facilities in Europe, among which is the one in Jyväskylä. An infrastructure based on a tandem linear accelerator of heavy ions is in operation at the University of Helsinki where modern nuclear physics techniques and instrumentations are employed to address problems concerning material characterisation and modification. The tandem accelerator is also employed as a mass accelerator spectrometer, particularly for dating using the ^{14}C analysis technique.

The laboratory for accelerator-based physics and related applications in Jyväskylä is an important and unique facility, one of the few highly international infrastructures in Finland and the only large-scale infrastructure for nuclear physics in the Nordic countries. It established itself as a Centre of Excellence in 2000 and has since then progressively increased its international leadership. In the international context, the contribution of accelerator-based research has been very crucial in addressing key scientific issues and in developing necessary cutting-edge technologies. The research at Jyväskylä is very well organised and productive and focused on the following well-integrated themes: rare-isotope beam science; nuclear structure at the limits for proton-rich and super-heavy nuclei; ion-beam developments and applications; and theory for nuclear structure and rare decays.

New physics has been and will be extracted by combining systematic accurate measurements on ground-state properties and excited states of nuclei far from stability including in particular super-heavy elements. Theoretical guidance and interpretations are provided and play an important role.

Developments for accelerators and related ion sources are essential both for basic and applied science programmes. A wide variety of ion beams with a large range of intensities and energies is available and this is vital for accomplishing the ambitious present and future research goals. The K=130 heavy-ion cyclotron with dedicated ion sources provides an instrumental backbone for the nuclear physics activities, while the new K=30 cyclotron and the

Pelletron accelerator essentially complete the accelerator structure of the Jyväskylä accelerator laboratory, allowing an excellent programme on isotope production and high-precision measurements for rare isotopes.

The activities at Jyväskylä on nuclear physics applications are entering new areas in materials and biophysics and other fields. Commercial services are also provided, including radioisotope production. The Jyväskylä accelerator laboratory is also largely contributing to complex technical developments for CERN-ISOLDE (Isotope Separator On Line-Detector) and has started to contribute to future research programmes at the ESFRI facility FAIR. This latter activity is carried out in collaboration with Helsinki Institute of Physics.

Overall, the research quality in nuclear physics and its international impact are very high and this attracts many students, postdoctoral researchers and senior staff, a good proportion of them from abroad. In general, the graduates readily find employment and fulfil societal needs. However, efforts should be made to provide sufficient funding to maintain these very high standards, reached after years of committed work, and to allow for the well-defined and planned future programmes to be carried out.

3.7 Optics and photonics

Optics is one of the oldest branches of physics, and is dedicated to the investigation of the properties of light (loosely understood to extend from the ultraviolet to the infrared regions of the spectrum) and its various interactions with matter. Over the centuries, optics has been shown to be an extremely rich area of knowledge and it has generated a variety of subfields, both in relation to the various theoretical descriptions of the relevant phenomena (from simplified geometrical optics to the classical interpretation of light as an electromagnetic wave and to quantum descriptions) and in relation to applications (from optoelectronics, whose remit is the study of devices that convert light into electricity or vice versa, as two interchangeable means of coding information, to photonics). Photonics, intended as the branch of optics dedicated to the generation, transmission and modulation of light as an information carrier, has been enabled by powerful advances in materials and their manipulations, down to the nanoscale, that have become possible in the last decades, and can be regarded as the cutting edge of applied optics.

The level of Finnish research in optics and photonics is generally high, with some peaks of outstanding quality in terms of output, international leadership and potential for development. There are small but strong units working on the computational aspects of optical phenomena, whose interactions with experimentalists should be encouraged and supported at a high level with appropriate and strategic funding opportunities. On the more applied side, there is a strong and strategic presence in optoelectronics. Although concentrated to some units, this is well linked with several other universities, and underpins a rich substrate of technology transfer opportunities, thereby crucially contributing to the generation of a healthy societal impact of the funds invested in this area. It will be crucial for Finland to maintain a strong level of funding in this area, so as to foster excellence in such a strategic sector, which provides the underpinning technologies in the transition from the post-industrial to the information-dominated society. This is clearly a strength that Finland should capitalise on, also in view of the nature of the industrial competence base, for instance in the mobile phone sector. To do this, a high-level vision needs to be developed, presumably with decisive input from the Academy of Finland, and with careful attention to the needs of society on a global rather than national scale.

Optics being such a broad area, coverage of the various subfields is necessarily incomplete in Finland, but there are areas that are not developed to a "critical mass" level. An obvious example is organic optoelectronics, which despite the excellence of the only group working in this area, is not well represented on a national scale, despite offering significant opportunities, not only for the display industry, which is now very strong in the far east, but also in the energy sector, for example thanks to photovoltaics. The very good nanofabrication facilities available or planned in more than one location would also suggest that there could be a significantly stronger presence in the area of "plasmonics".

Most units are well or very well equipped and generally satisfied with the available infrastructure, the perception being that support administrative staff to help competition on a European level would be the most valuable commodities to help the groups excel on the international arena. There is a healthy culture of national cooperation throughout the units involved in optics and photonics that is also well complemented by actions to develop a network of international relations.

In general, the quality of research in optics and photonics in Finland is of a very high standard and has potential for additional development if adequate support is provided.

3.8 Space physics

Modern space physics comprises ground-based and space-borne observations of the near-Earth and interplanetary plasma environment as well as their theoretical description. Beginning with the necessity to understand the propagation of information-carrying electromagnetic waves in and through the ionosphere and the role of precipitating energetic particles and cosmic rays in the Earth's atmosphere, space physics increasingly became, with the exploration of the near-Earth and interplanetary space, a societally important research field for which the terms space weather and space climate were coined. The reason is that mankind places more and more of its technically decisive systems into space. Also, space physics research drives new technologies in space-safe instrumentation, transportation, communication, navigation and information systems.

Due to its high latitude location, Finland provides a unique basis for ground-based observation of the space above the Earth. As a result, Finland runs an internationally important observatory in Sodankylä in the far north of the country. Based on the accumulated experience in the field of geophysical observations and instrumentation, Finland strategically joined ESA, the European Space Agency, in 1995 in order to participate in this new field of technology development. Since then, Finland has become an important part of the internationally booming space research field.

Especially the Kumpula Space Centre of the University of Helsinki and the Finnish Meteorological Institute, joined by the Aalto University space physics group in 2012, has become an internationally recognised space research centre that develops well following a clear holistic strategy. In addition, there is a second centre of space physics in Finland, the University of Oulu groups together with the Sodankylä geophysical observatory, which successfully carries out research also in the ground-based research segment. The research quality of these two centres has reached the highest international standards, which is well recognised Europe- and worldwide, in scientific literature and by the exchange of scientists and data.

A much smaller third group, at the University of Turku, is specialised in the instrumentation for and observation of energetic particles and cosmic rays in space. However, the evaluation panel feels that without consequent support directed at stabilisation and growth, the group is in acute danger of becoming of subcritical size. Urgent personnel stabilisation or a merger with one of the two national centres in Oulu or Helsinki would safeguard the international Finnish commitment in this field. On the other hand, research mobility, both inward and outward, is strongly encouraged in this very international and labour-sharing field of research.

The consolidation of space research in times of slower growth in funding resources requires, however, further concentration and the development of commonly agreed strategies. The panel supports the upcoming extension of the Kumpula Space Centre by including the space physics group of Aalto University. A similar consolidation process is encouraged for the Oulu-Sodankylä groups.

The instrumental infrastructure for space projects in Finland is traditionally funded by Tekes, the Finnish Funding Agency for Technology and Innovation. Among Tekes-funded projects, there are a number of space-physics-oriented projects, such as BepiColombo, an ESA mission planned to be launched in 2015 for a flight to Mercury. A major problem for the sustainability of successful Finnish space research is, however, the stability of the funding for research infrastructures, space-technology-approved technicians and highly qualified and specialised scientists, since the analysis of space data also requires stable funding. High-level political decisions are therefore encouraged in favour of a stabilisation of the Finnish physics programmes with excellent contributions to space research. The evaluation panel therefore recommends that the national agencies for space research, funding both scientific research and technology development, work together on a strategy to provide the successful Finnish space physics programme a long-term perspective and financial stability.

At the university level, this includes the establishment of more permanent positions, including the re-filling of a professorship lost in 2010 at the Kumpula Space Centre, in order to maintain the accumulated Finnish expertise and competence in space physics. If, however, the existence of the University of Turku space research group cannot be secured by a stable and guaranteed third-party instrument funding for the Solar Orbiter mission and by hiring one or more young, prospective researchers and a professor in a permanent position, it seems to be advisable to merge the group, for example, into the Kumpula Space Centre in Helsinki, which already hosts a supercritical space research environment.

4 UNIT EVALUATIONS

4.1 Aalto University, Experimental Materials Physics

Overview

Six of the research groups at the Department of Applied Physics of Aalto University (AU) have been evaluated as a single unit. These are rather independent groups with little joint structures and strategies below the department level. These groups are: Atomic Scale Physics; Surface Science; Molecular Materials; Nanomaterials; Nanomagnetism and Spintronics; and Positron Research. The Department of Applied Physics belongs to the AU School of Science. On average, for the six groups together during the evaluation period, there have been a total of four professors, nine senior researchers, eight postdoctoral researchers, 31 PhD students and 14 technicians. Slightly less than 20 per cent of the unit's budget is core funding. External funding is mainly provided by the Academy of Finland and Tekes, in addition to other Finnish and EU programmes.

Research profile

The unit's research profile is rather broad, but there are clear focus areas, such as nanotechnology. It includes activities such as graphene growth and modification of its electrical properties, synthesis and structural characterisation of carbon nanotubes, spin-transport phenomena in new functional materials, biomimetics and self-assembly for functional materials. An additional activity is the positron annihilation spectroscopy of vacancies and defects in semiconductors.

Research quality

Overall, the unit's research output is high and the research quality is very good. Of course, there is some variation and the assessment of the research quality ranges from good to excellent for the different groups. Evidence for the high research quality is not only given by the very good overall publication record, but also by the large number of invited talks at international conference by some members of the groups. In addition, the amount of external funding gathered by the six groups is impressive, being far more than the core funding.

Research environment

The research environment is very good. The groups of the unit appear well equipped with state-of-the-art research tools. The average teaching load seems moderate and has no negative impact on the research capabilities of the groups. The fact that the groups are located in different buildings is not ideal and hinders interaction on a daily basis. They are able to attract a sufficient number of good graduate students.

Research networking and interaction

All groups in the unit have individual international and national collaborations at some level. Some of the groups are extremely well connected by European networks and by strong individual collaborations. There are many interactions and common projects among the groups and with other groups at AU, in particular withthe two Centres of Excellence, COMP and the Low Temperature Laboratory.

Research infrastructure

The different groups have up-to-date laboratory infrastructure. In addition, some of them make use of large-scale infrastructures such as the newly formed

Nanomicroscopy Center and cleanroom facilities at AU.

Recommendations

The evaluation panel recommends that several of the groups that appear to be of subcritical size consider joining forces, especially since there seems to be sufficient overlap in the research activities. In addition, the panel recommends that AU together with the Department of Applied Physics make a clear plan for tenure-track positions within these groups. At present, it seems that many details of the transition to a tenure-track system are not clear and should be made transparent. Finally, the groups of the unit would benefit from being located in the same building.

4.2 Aalto University, Centre of Excellence in Computational Nanoscience

Overview

The Centre of Excellence in Computational Nanoscience (COMP) at Aalto University (AU) is hosted by the Department of Applied Physics. It has nine faculty members and employs 90 scientists and students. The Centre is well funded with an annual research budget of about EUR 6 million, with 15 per cent coming from Centre of Excellence funding. The present director, who has been in charge of the Centre from its inception, will step down in 2014, but a new director has already been named.

Research profile

The unit develops and applies advanced theoretical and computational methods to condensed matter and materials physics, especially in nanoscience and nanotechnology. It consists of nine research groups that cover the electronic properties of materials, surfaces and interfaces at the nanoscale, quantum many-body physics, quantum computing and devices, quantum dynamics, multi-scale statistical physics, and complex systems and materials. The focuses of the research are: (i) understanding, predicting and designing materials properties from first principles, both in their ground state and in their excitations and dynamics; (ii) exploration of the entangled quantum world and well-defined quantum testbeds in the quest for new concepts and devices; and (iii) application of statistical-physics ideas and methods to investigate new and multi-scale phenomena in materials, processes and complex, coupled and adaptive systems. Until recently, biological physics was one of the groups of the unit, but the leader left to join the Department of Physics at Tampere University of Technology. Many of the remaining groups collaborate closely with experimental efforts, providing theoretical modelling to support and explain experimental results.

Research quality

The research quality is excellent. The unit has been selected three times as a Finnish Centre of Excellence. It is quite productive and has been very active in its fields of interest. Between September 2009 and March 2012, it had over 200 refereed publications, of which 30 were in high-impact journals. Members have been selected to give invited and plenary talks at international conferences, and have garnered prestigious accolades such as membership in the European Academy of Sciences, the Vaisala Physics Prize and the Finnish Cultural Foundation Prize.

Research environment

The unit's research environment is enhanced by having experimental groups on the same campus, which facilitates collaboration. However, the unit is spread over several buildings, which diminishes spontaneous interactions that can foster innovation. About one-third of the unit's effort is spent on method and code development while the rest is devoted to modelling experimental results and applications. The unit is active in a number of national doctoral programmes and typically graduates 7–9 PhDs per year. The typical time to complete a PhD is about five years. The graduate students who speak Finnish have light teaching duties that amount to 5–6 hours per week. Currently, graduate students are paid through national doctoral programmes, but this will change as money from the Academy of Finland for graduate students is planned to be channelled through universities rather than through grants. The number of physics majors has been slightly decreasing in an effort to increase the teacher-student ratio, though this may reduce the number of available graduate students in the future. An increasing proportion of students, both at the undergraduate and graduate level, are recruited from abroad.

The administrative and secretarial support is sufficient for the director but not for group leaders who do much of the administration on their own. AU provides support for grant preparation, some of which is from administrators with PhDs who have the necessary expertise.

Research networking and interaction

The national, international and industrial collaborations are extensive. As part of collaborative research programmes, the unit's students visit international collaborators. The unit has organised a large number of international workshops and conferences, and has an international board of scientific advisers and members from 17 countries. The senior leaders are members of national boards and councils that affect national policy, for example, advising the Prime Minister on science and technology policy, and advising the Academy of Finland on funding. They also are active on international scientific advisory boards.

Research infrastructure

The unit has excellent state-of-the-art infrastructure both in-house as well as at the IT center for science CSC. New local computing facilities include petascale machines, doubling the size of the Linux cluster, and using NVIDIA/CUDA GPU nodes. The unit also has access to the pan-European high-performance computing infrastructure PRACE. Since the unit actively models experimental results, it would benefit from improvements in the experimental facilities of its collaborators.

Recommendations

The unit would greatly benefit if the various groups as well as their experimental collaborators were housed in a single building. This would foster more spontaneous interactions that could lead to new ideas and discoveries. Although the leader of the unit has good administrative support, the other professors and group leaders would benefit from increased secretarial and administrative support that would allow them to devote more of their effort to research.

4.3 Aalto University, Department of Micro- and Nanosciences (Micronova)

Overview

The unit focused on physics is one of the two units in the Department of Micro- and Nanosciences and is situated at Micronova, Finland's national research infrastructure for micro- and nanotechnology. The other unit focuses on electronic circuit design. Micronova is jointly operated by Aalto University (AU) and VTT Technical Research Centre of Finland. The

Micronova unit currently has four professors, two senior researchers and some 30 doctoral students. There are two tenure-track openings in photonics and micro- and nanoelectronics, and searches are currently underway to fill these. The current funding of approximately EUR 4.3 million per year comes primarily from AU, the Academy of Finland, Tekes and national doctoral training programmes.

Research profile

The Micronova unit is involved in micro- and nanofabrication as well as in increasing energy efficiency through nanoscience. The unit uses a variety of nanofabrication methods including electron beam lithography, focused ion-beam lithography, atomic layer deposition (ALD, several units and a new one about to be acquired), metalorganic vapour phase epitaxy (MOVPE, two units and a third one to be acquired) and other advanced deposition and dry-etching processes combined with standard microfabrication techniques. Semiconductor nanostructures such as quantum dots and nanowires are also processed by self-assembly. Research projects include nanowires grown on glass, a gas refractometer, plasmon-enhanced emission from LEDs, proof of principle for wireless images in a contact lens, organic solar cells, and thermoelectrics with enhanced electrical conductivity and reduced thermal conductivity, as well as graphene. Using its Focused Ion-Beam (FIB) facility, the unit is also able to fabricate a variety of high-aspect nanostructures for various applications.

Research quality

The research quality is very good. The Micronova facilities, including cleanrooms, are among the best in the Nordic countries. The average number of refereed publications is about 50 per year; these are featured in high-impact-factor journals. Approximately ten PhD theses per year are related to microfabrication.

Research environment

Although the unit's research funding is adequate at the time of this report, additional funding needs to be secured. The overhead charged on grants is approximately 70 per cent. There is not enough money from grants to pay for the full experimental costs, for example for infrastructure such as the cleanroom. The graduate programme graduates about six PhDs per year.

Research networking and interaction

Because the unit provides national-level research infrastructure, there are many national and international visitors. About 30 per cent of the visitors are from abroad (Europe, North America and Asia) and about 40 per cent of the unit's publications have foreign co-authors.

Research infrastructure

Micronova is one of Finland's 24 national-level research infrastructures and thus provides open access to the main facilities for scientists from research institutes, universities and companies. The core element of Micronova is the largest R&D cleanrooms in the country and the extensive arsenal of processing and measurement equipment for micro- and nanofabrication. The recent FIRI funding for a large electron-beam lithography facility and a metal ALD tool further enhances the equipment list. An upgrade of Micronova is being actively developed by a joint planning group of AU, VTT, the City of Espoo and Senate Properties to enhance research into sensing technologies for biotechnology, chemistry and life sciences ("Sensonova"). At the moment, the cleanrooms are used by about 160 researchers, mainly from different AU departments and VTT's Knowledge

Centres. In addition, scientists from the University of Helsinki and the University of Turku, as well as a number of researchers from industry, utilise Micronova's facilities.

Another important national research infrastructure used by the unit is the AU Nanomicroscopy Center, which is located close to Micronova. The centre is a large microscopy cluster housing various high-resolution microscopes for soft, hard and biomaterial characterisation, including an ultra-high-resolution transmission electron microscope (TEM), a liquid helium cryo-TEM, high-resolution scanning electron microscopes, environmental scanning electron microscopy, a scanning probe microscope, a UHV (Ultra High Vacuum) scanning tunnelling microscope, and X-ray scattering equipment. These facilities complement the facilities of Micronova for advanced materials research into nanomaterials and functional coatings prepared in Micronova.

Recommendations

The unit would greatly benefit from more secure long-term funding for its infrastructure. The cleanroom receives most of its support from the AU School of Engineering. The budget is typically negotiated each year about one month before the start of the fiscal year. There is a clear need for a more stable systematic funding model for the impressive infrastructure of Micronova and this unit.

4.4 Aalto University, Optics and Photonics

Overview

The Optics and Photonics research group of the Department of Applied Physics at Aalto University (AU) includes two full professors, two senior researchers and on average three postdoctoral researchers and nine graduate students. One of the professors is a FiDiPro Professor with a 50 per cent joint appointment with the University of Eastern Finland in Joensuu and is currently on leave from Stockholm. Over the evaluation period, the unit published more than 90 papers and delivered training leading to eleven MSc degrees and nine PhD degrees, in addition to generating one patent and one spin-off company. The unit also contributes to undergraduate and graduate training by teaching regular courses, and to significant administration tasks, one professor being head of the Department of Applied Physics since 2008. In 2010, core funding accounted for approximately 42 per cent of the total funding and stood at EUR 450,000.

Research profile

The unit has three primary objectives spanning both the theoretical and the very applied. These objectives are dedicated respectively to: (i) fundamental aspects of electromagnetic fields, including both theory and experiments; (ii) light-induced effects in azo-polymers; and (iii) applied optics such as development of DPSS (diode-pumped solid-state) lasers and laser scanning interferometry of micro-acoustic devices. The unit is committed to the fundamental understanding of electromagnetic phenomena and has extended the range of activities to include experimental optics and photonics to combine the possibility of validating theory and prosper in the competition for funding.

Research quality

The unit published in high-profile journals at the beginning of the evaluation period and is, considering its very small size, "punching above its weight". However, the size of the unit appears to be below the critical mass necessary to ensure a lively intellectual environment capable of surviving in a changing and ever more competitive funding environment and make the most of the opportunities available for collaboration with experimentalists at AU, especially of the specialised equipment and expertise for micro- and nanofabrication. Overall, the quality of the research is currently good.

Research environment

The theoretical or computational work requires relatively modest resources and is well funded. Similarly, the experimental work of the unit can benefit from Micronova, the AU centre for micro- and nanotechnology, which makes available a varied and high-quality number of technical resources. More support from central administration would be needed for more extensive networking within Europe to be funded via EU tools. The unit has a good intake of students, and delivers a good number of degrees. Most students go to industry after their studies. In terms of career progression, there is now a tenure-track system in place, although it is only two years old. The teaching load is well manageable, at about two courses per year per professor.

Research networking

There are good collaboration networks involving both professors and junior researchers, both at national and international level, albeit none of these is very large. The FiDiPro Professor has a joint appointment with another Finnish university and is currently on leave from Stockholm. The current administrative load of the academics hinders the further expansion of the collaboration network.

Research infrastructures

The unit is embedded within Micronova, which gives it access to very good facilities for nanomanufacturing and -characterisation and could be particularly important for the further development of the experimental research programmes in photonics and nanophotonics. Provisions for administrative support from AU are perceived as being mostly sufficient, although additional support would be welcomed by the unit, especially in dealing with the bureaucracy required by EU funding at both the application and the implementation stages.

Recommendations

The unit should try to gather additional critical mass by seeking appropriate funds or commitment from AU for one, ideally two, experimental positions to appoint internationally leading experimentalists in photonics and nanophotonics. There are opportunities to be seized in nanophotonics and especially plasmonics, which would allow the unit to leverage its excellent track record in the theory of electromagnetic fields while at the same time capitalising on the excellent infrastructure and wealth of projects and expertise within Micronova.

4.5 Aalto University, O.V. Lounasmaa Laboratory

Overview

At beginning of the evaluation period, the O.V. Lounasmaa Laboratory (also known as the Low-Temperature Laboratory LTL) was an independent research institute of Helsinki University of Technology. Now, it belongs to Aalto University (AU), which was created in 2010 by a merger of Helsinki School of Economics, Helsinki University of Technology and the University of Art and Design Helsinki. The laboratory operates as part of the AU School of Science and its teaching activities will soon be integrated into the Department of Applied Physics. The research staff include five professors and six senior researchers. In addition, the unit includes nine postdoctoral researchers and approximately 20 PhD students. A little less than half of the budget is core funding, while the external funding is fairly evenly split between the Academy of Finland and other Finnish and EU programmes.

Research profile

The unit's research profile covers a broad scope of low-temperature physics, with an emphasis on quantum liquids, quantum electronics, and nanophysics. The unit is subdivided into six experimental groups and one theoretical group of about similar size. The quantum liquid activities concern the properties of superfluid helium-3 at ultra-low temperatures, such as the study of quantised vortices in a rotating nuclear demagnetisation cryostat. In addition, there is the search for a novel superfluid phase in helium-3/helium-4 mixtures at ultra-low temperatures. Other interesting topics are microwave amplification of nanomechanical resonators, which are operated near the quantum limit, and chip electronic cooling via superconducting tunnelling junctions. The development of hybrid single-electron transistors as accurate electron pumps and their application in metrology is also pursued in one of the experimental groups. The theoretical group covers a wide range of subjects mostly related to experimental investigations, but also some seemingly unrelated topics such as quantum chromodynamics and its application in cosmology. Overall, the research profile of the unit is impressive by being original, broad and well interrelated at the same time.

Research quality

The unit's research output is very high and internationally leading all across the seven different groups. The publication rate is impressive and most publications are in top journals. There are some differences between the groups, but these can well be explained by the styles and typical rates in certain subfields. Especially in very time-consuming experiments, the publication rate is naturally somewhat lower. Further evidence for the excellence of the research quality of the unit is provided by the success in obtaining external funding, by the large number of invited lectures at international conferences, by numerous prizes given to members of the unit and most recently by two young group leaders being awarded ERC starting grants.

Research environment

The research environment is excellent. There are vast opportunities for on-campus collaboration with very good groups such as the ones of the Centre of Excellence in Computational Nanoscience. Being an independent research institute, the teaching load of the members of the O.V. Lounasmaa Laboratory has been particularly low in the past, but it might increase when the teaching activities will be integrated into the Department of Applied Physics. The new laboratory building provides sufficient quality space for the large-scale ultra-low temperature infrastructure. The unit has access to the Micronova cleanroom facility and actually is one of the major groups that actively shape this facility. In terms of students, it seems that the unit is able to attract a sufficient number of good graduate students who want to join the group.

Research networking and interaction

The unit's collaborations are exceptionally strong. Besides a large number of individual international contacts and collaboration partners, the unit is involved in several Europe-wide projects. One such project is the so-called Microkelvin Collaboration, which aims at the opening up of nanoscale physics to ultra-low temperatures and which consists of twelve European partners from eight countries. Within this project the unit gives Europe-wide access to its unique cryogenic infrastructure. In addition to these international collaborations, there is strong interaction with other groups in Finland and at AU.

Infrastructures

The unit needs two types of rather involving infrastructures: cryogenic equipment for ultra-low temperatures and a nano- or microfabrication facility in the form of a high-class cleanroom for producing individual nanodevices. In terms of the cryogenic environment, the unit has recently moved into a new building with a large hall in which there is a good-quality lab space to operate cryogenic equipment, which is organised as an infrastructure called CRYOHALL. Some of the cryostats used by the unit are quite unique and have been developed over many years, such as the rotating cryostat for investigating superfluid helium-3. Overall, the cryogenic infrastructure is world-class and well maintained. CRYOHALL is quite rightly recognised as one of Finland's national research infrastructures. For other needs, the unit has a small in-house cleanroom, but more importantly, it is also a substantial user of Micronova. Although the Micronova facility is operated under the umbrella of the AU School of Electrical Engineering, the unit has a large share of the time and has contributed significantly to the development of specific processes. Overall, the infrastructure acquired, maintained and used by the unit is excellent.

Recommendations

The unit should maintain its direction and level of achievement, which is impressive in such an important and challenging area of research. The evaluation panel recommends that AU consider strengthening the unit's activity by adding tenure-track positions. This is important in particular in view of the coming transition from an independent research institute to a laboratory of the Department of Applied Physics and in the light of upcoming retirements. The panel further recommends that the fractured funding for maintaining and further developing the unique large-scale cryogenic infrastructure be put into the core funding of the unit, either through national or university funds, to guarantee its world-class standard for the future.

4.6 Helsinki Institute of Physics

Overview

Helsinki Institute of Physics (HIP) is a national research institute operated by the University of Helsinki (UH), Aalto University (AU), the University of Jyväskylä (UJ), Lappeenranta University of Technology (LUT) and Tampere University of Technology (TUT). Administratively, it is an independent unit within the UH. It has a national mandate from the Finnish Ministry of Education, Science and Culture to coordinate Finnish groups' collaboration with CERN and, in the future, with the Facility for Antiproton and Ion Research (FAIR) in Darmstadt. HIP operations are based on the national CERN strategy to further international collaboration in nuclear and particle physics together with graduate training of students. HIP is located on the new modern Kumpula Campus, in the same building as the UH Department of Physics. The unit has a full-time administrative manager. All teaching and research activities are closely integrated with those of member universities.

Most of the unit's programme and project leaders have joint faculty positions at the UH or the UJ, a few also at other member universities. The average personnel resources at the doctoral level during the period were in total close to 30, of which a majority were postdoctoral researchers. Last year, there were 40 doctoral students of which nine got their PhD. In addition, there were 14 students who got an MSc in the unit. These numbers are characteristic of the whole period. The unit has recently got a new director with a scientific background in experimental nuclear/particle physics while the previous director was a hadron/particle physics theorist. This should to a large extent guarantee that the research profile will not change too much in the coming years.

Of the total funding resources during the evaluation period, almost 80 per cent was core funding. The remaining part comes from external sources, of which the Academy of Finland and the EU are the biggest ones. During the evaluation period, the support from the Academy has nearly tripled. The unit has also succeeded in getting substantial funding from other public sources and private foundations. This financial support for the unit should be secured for the coming years so as to allow for planning over longer periods. There is also a need to strengthen the presence of foreign faculty members and younger researchers with more permanent contracts.

Research profile

The research at HIP is to a large extent set by the interests of the four founding universities. In particular, the activity in the elementary particle division of the UH defines much of what is being pursued at the unit. A large part of the experimental activity is concentrated around the big Compact Muon Solenoid (CMS) detector at the CERN/LHC accelerator. In addition to physics analysis, the unit also contributes to the detector operations and the coming tracker upgrades. A parallel activity takes place around the TOTEM experiment for forward physics at the LHC accelerator. The unit also participates in the ALICE experiment at LHC under the lead of the UJ group. The unit is also responsible for the Finnish contribution to the FAIR project in heavy-ion and antiproton research. The panel finds such investments important for the whole country, noting that Finland is one of the few countries in Europe getting more back from CERN than what it invests in it.

Theoretical research at HIP is pursued in several programmes. The most prominent ones are closely tied to the CERN experiments and seek to complete the Standard Model in finding the Higgs boson, study quark-gluon plasma phase diagrams and search for new physics coming in at even higher energies. This effort has direct implications for understanding the physics in the universe just after the Big Bang and is well recognised throughout the world.

A closely related activity is the more phenomenological analysis of data from the older WMAP (Wilkinson Microwave Anisotropy Probe) and the newer Planck satellite investigating cosmic microwave background radiation. The unit is an active member of both collaborations and is already involved in the next-generation Euclid telescope for the study of dark energy and matter in the universe. One of the unit's strengths is the close integration between research in high-energy physics and research in cosmology. The panel finds this research direction very successful and one that should be given an even bigger emphasis in the coming years. Finally, the unit is also active at CERN in the CLOUD (Cosmics Leaving Outdoor Droplets) experiment on the effect of cosmic rays on aerosol formation.

Research quality

Finnish research in high-energy physics has over a long period shown to be of the highest quality in close contact with the experimental situation. This also shows up in the unit's output of publications, which in the last couple of years have been around 200 per year in refereed journals. As part of the CMS collaboration at CERN, the experimental activity has earned worldwide attention for the first, tentative data indicating the existence of a Higgs particle. The experiment has the potential for further, fundamental discoveries when the energy is increased at the LHC accelerator. Especially visible has been the activity in computational field theory where technicolour theories are being investigated as an alternative to the standard Higgs mechanism. In cosmology, problems around dark energy have been studied in connection with the cosmic microwave background data to which the unit has access. Within the Planck collaboration, three of the unit's members have been awarded the status of Planck scientist. Of noteworthy results obtained by other member universities, the panel noted the nuclear parton distributions being calculated at the UJ and the electronic boards produced and tested at the rather small unit at LUT for the CMS experiment.

Research environment

HIP receives its main support directly from the Ministry of Education, Science and Culture, and the support has remained level during the evaluation period. In addition, it receives some support from its member universities. Especially the extra support from the UH Department of Physics is crucial because of the close integration between the two. The unit has earned the status as an institute of advanced studies and has seen little or no decline in its intake of new students. The students graduating from the unit get academic degrees from their member universities. Based on excellent teaching at the universities and the unit, combined with specialised seminars, the students are among the best trained in the world. They come early in direct contact with ongoing research and the doctoral training is therefore an integral part of these programmes. Many of the PhD candidates succeed in continuing in postdoctoral positions abroad in strong competition with applicants from the very best universities. This is a part of a desired career path where some of the students can come back to HIP as project leaders and end up as professors in permanent positions.

In the present situation, the unit has adequate administrative help. With all the time-consuming interactions with international organisations and foreign groups, this support is important for the functioning of the unit. Today, such help seems to be uncommon in Finland. Here, it is crucial that the unit continue to function at the level it does today.

Research networking and interaction

The unit is by its very construction closely integrated with many Finnish universities and institutions, both in teaching, research and technological development. Separate parts of the unit have and are members of different European and Nordic networks. Members of the unit participate in different international arrangements and schools, while having an active outreach programme at home, inviting schools to visit them and giving public lectures. However, for such a central unit involved in so many exciting projects, this activity should be increased and made more visible. This would strengthen the standing of the unit and inspire new generations to pursue this kind of fundamental science.

Infrastructure

HIP's main experimental facilities are mostly at CERN, while, at home, the Detector Laboratory will continue to provide premises, equipment and extensive know-how for research projects related to detector development and construction for particle and nuclear physics. UJ accelerator laboratory test beams are also regularly employed for these purposes. This situation will most likely change when activity at FAIR is increased in the coming years, although the involvement here together with Sweden is rather modest, or more dramatically if the neutrino detectors of LAGUNA are installed in the Pyhäsalmi mine. HIP backs this project, although it is not directly involved in it.

Recommendations

HIP should continue its programme in high-energy physics with an emphasis on new physics beyond the Standard Model with the aim of understanding more of the universe as part of modern cosmology. Experimental particle physics will be very important in the coming years in this endeavour and should be more closely integrated with the theoretical activities in the formation of a Centre of Excellence. There should also be a strong component of applied research in accelerator, detector and computing technology. The development of technology know-how for Finnish industry and business applications is stressed as well as the exploitation of research results in science education and public awareness. Especially talented and young researchers should be led onto tenure-track career paths. In addition, the staff should be strengthened by having more long-term foreign guests.

4.7 Lappeenranta University of Technology, Laboratory of Physics

Overview

The Department of Mathematics and Physics of Lappeenranta University of Technology (LUT) was founded in 2006 after the field of physics was separated from electrical engineering and joined with mathematics. The Department's contribution to the main strategy of LUT (i.e. scientific computing and collaboration with Russia) is to combine basic research in computational science and materials physics with real-life applications. The Department's Laboratory of Physics consists of two professors, one senior researcher, two lecturers and six postdoctoral fellows. In 2011, the total funding was around EUR 1 million, of which 20 per cent was external funding.

Research profile

The unit carries out research on magnetic and transport properties of semiconductors and properties of unconventional superconductors, developing optical measurement techniques such as spectroscopy and sensor technology. The unit's research programme is concentrated on future-oriented thematics. There is an established collaboration with 14 Russian institutes and universities related to the unit's well-known experience of experimental work concerning magnetic properties and superconductivity.

Research quality

From a small group providing basic education, the unit has rapidly transformed into a laboratory with international visibility, accelerating research output, international MSc and PhD programmes, and actively expanding its international research networks. The research productivity is at a good level, particularly considering the small size of the unit. Several relevant contributions have been given to: (i) nanotechnology for electronic devices; (ii) developing and constructing optical link boards for the LHC CERN experiment CMS; and (iii) computational analysis methods enabling new possibilities for quantitative hyperspectral microscopic imaging.

Research environment

The unit has several graduate students, particularly from Russia, and visitors. The teaching load is in general heavy and the funding for new instrumentation is rather marginal. In the unit, academic careers are based on a tenure-track system. A number of PhD graduates from the unit have found a position abroad.

Research networking and interaction

The unit has well-established interactions with universities in Russia and with other Finnish universities. The recent activity in the CMS experiment at CERN has tightened the collaboration with Helsinki Institute of Physics as well as the unit's international connections. The research in optical measurements has connections to the University of Eastern Finland. The unit's graduate students have good possibilities for stays abroad, which creates ample career opportunities for the future. The research carried out in this unit has relevant societal impact.

Research infrastructure

The unit has unique experimental installations for pulsed magnetic fields up to 45 T and a SQUID (superconducting quantum interference device) magnetometer. Operation and use of this facility in a reinforced networking scheme with the other facilities performing high-magnetic-field research is desirable in view of future developments.

Recommendations

More visibility could be gained by increasing the focus of the research programme and the size of the unit. The activity on high magnetic fields should be better integrated with the international network carrying out such cutting-edge technological development. The optimal operation and maintenance of this infrastructure needs additional resources. The evaluation panel recommends that future plans in particle physics be defined in collaboration with other Finnish universities in order to improve the visibility of the unit in an international context. Funding for instrumentation should be provided on a rather regular basis and the number of postdoctoral fellowships should be increased.

4.8 Tampere University of Technology, Aerosol Physics Laboratory

Overview

The Aerosol Physics Laboratory of the Department of Physics at Tampere University of Technology (TUT) is a rather small laboratory consisting of two professors, two postdoctoral researchers, 13 PhD students and a small number of graduate students. One tenure-track academic will start in 2012, and one postdoctoral position is currently vacant. The unit's research is concentrated on conducting applied research in aerosol science and technology and trying to combine academic and industrial research, thus supporting and initiating industrial activity. The overwhelming portion of funding is external (around 80%), mostly from industry-related sources and hence less directed towards academic research.

Research profile

The unit's two main branches are dedicated to aerosol measurement methods leading to new instruments and nanoparticle formation and properties, also with close ties to industrial applications. The main research topics include aerosol measurement methods and instrumentation, fine-particle emissions, atmospheric aerosols, nanoparticles synthesis and nanocoatings. The research is mainly application-driven and has fewer basic research components. The unit's key expertise is within electrical and inertial aerosol measurement techniques, which have recently extended to optical techniques in close cooperation with the TUT Optics Laboratory. The techniques are used to monitor particle emissions in industrial and environmental applications. Recently, it became possible to determine the physical phase state of secondary organic aerosols. This result may pave the way to more intense cooperation also with the academic sector in Finland. The basic tools of the aerosol synthesis group are furnace and flame reactors, allowing the generation of single- and multi-component particles for industrial and laboratory applications. Overall, the unit has developed very solid technological expertise, which obviously has generated much interest in the industry. The unit is quite successful in initiating spin-offs and industrial cooperation.

Research quality

The unit's research is basically driven by opportunities provided by applied projects, while the theoretical studies remain to be further developed. The research is concentrated on niche topics, which allows the unit to be reasonably competitive with small investments. Although the unit performs most of its research together with or funded by industry, which often hampers publication of the most relevant results, the publication record was 64 journal papers since 2007. In 2012 alone, a further ten publications have been submitted so far, so there has obviously been a strong increase in publication activity. The impact factors of the journals where these publications have been featured are, however, rather low in about half of the cases. During the evaluation period, the unit graduated only five PhD students. The number of patents (three and six applications) and invention disclosures (17) is a firm indicator of the unit's innovativeness and of strong industrial links. The fact that the unit has managed to receive 50 per cent of its external funding (some EUR 3.7 million) from Tekes is proof of its competitiveness in applied research.

Research environment

Having lost two senior members in 2011, the unit is in danger of being burdened by a heavy administrative and teaching load. In addition, one of the two remaining professors is also Head of Department, spending most of his time on administrative services. Filling the vacant positions as early as possible must have priority in order to keep the unit alive. The access to data and samples to be studied in the laboratory and used to test in-house-developed new devices is based on an exchange with industry and other academic institutions. The unit is quite successful in initiating spin-offs and industrial cooperation. Synthesis of nanoparticles in the Liquid Flame Spray Laboratory has led to collaboration with industry and academia, but it seems that the activity is so far more in service than research mode.

Research networking and interaction

The research and development activities of the unit have resulted in three spin-offs and direct technology transfer in further three SMEs. Established contacts exist with a number of industrial partners in Finland and Europe as well as with most of the relevant Finnish research institutes. This is a good basis for further collaboration as it allows for students trained within the unit to move directly to one of the industrial partners or to other research institutes, thus facilitating the formation of a stable network. There are international links, but this strand could be strengthened, mainly in order to increase the proportion of academic research.

Research infrastructure

The unit mainly operates standard instruments requiring relatively low investment. This is appropriate with regard to current research and development within the unit, but does not advance the necessary step into more theoretical studies that may lead into more high-risk, high-gain projects. Access to more complex instrumentation has been secured by collaborating with other research institutes in Finland and abroad. Sustained core funding is needed to expand the availability of laboratory facilities and instruments to allow for competitive research.

Recommendations

The teaching and administrative load on the academic personnel is quite high, especially since one of the professors has been appointed Head of the Department of Physics. This situation is not of benefit to the small unit and should be re-considered. The current vacancy of one academic and one postdoctoral position should be taken as a chance to support academic research. The number of postdoctoral researchers needs to be increased to ease the load caused by supervision of graduate students. Intensified collaboration with the strong Optics Laboratory at TUT may help advance the standing of the unit.

4.9 Tampere University of Technology, Computational Physics Laboratory

Overview

The Computational Physics Laboratory is part of the Department of Physics at Tampere University of Technology (TUT). During the evaluation period, it had three professors (though one is leaving soon) and one FiDiPro Professor. There were two senior researchers, two Academy Research Fellows and about a dozen doctoral students. A tenure-track associate professor position will be filled in autumn 2012, and the unit also needs a replacement for the professor who is leaving. An optimum size would be 5–6 faculty members. The unit is well funded. Between 2007 and 2011, external funding increased by an impressive 335 per cent, and core funding by 77 per cent. External funding comes from the Academy of Finland, national doctoral programmes, private foundations, the EU (incl. the European Research Council) and Tekes.

Research profile

The unit has a broad research portfolio. It develops and applies advanced theoretical and computational methods to biological physics, surfaces and interfaces at the nanoscale through virtual scanning probe microscopy, materials and molecular modelling, electronic structure theory, and spectroscopies of complex materials. In biological physics, the emphasis is on lipid-protein interactions, for example, lipids in a cell membrane can affect ligand binding to a receptor embedded in the membrane. One of the things investigated by the materials and molecular modelling group is phase-change materials in which there is very fast switching between an amorphous metastable form and a stable crystalline form. This has important potential applications for memory storage.

Research quality

The research quality is very good, and the unit's professors compare very well with the Centre of Excellence in Computational Nanoscience at Aalto University in terms of citations and h-index. The unit looks at important and significant problems and finds interesting results. The unit's researchers publish some 50 papers per year and their work appears in leading journals. A couple of faculty members have won awards for their research.

Interestingly, the unit values quality over quantity and, in the future, would like to publish fewer papers that have greater impact. Currently, the number of publications is largely driven by the unwritten rule that, before obtaining their degree, each PhD student should publish five or six papers, regardless of quality. The unit would prefer to have this down to 2–3 high-quality papers. This is certainly admirable but perhaps a bit risky. However, an effort is being made to match the difficulty of graduate research projects to the abilities of each individual student.

Research environment

The unit is active in five national doctoral programmes, has about 15 Master's and 20 PhD students, and typically graduates 1–3 PhDs per year. The typical time to complete a PhD is about 4–5 years. Graduates of the unit go on to research positions abroad, as well as to jobs in industry, information technology and academia. Graduate students are not required to be teaching assistants but many choose to do so. Being a teaching assistant takes about 4–5 hours per week. The graduate students who speak Finnish have light teaching duties that amount to 5–6 hours per week. Currently, graduate students are paid through national doctoral programmes, but this will change as money from the Academy of Finland for graduate students will channelled through universities rather than through grants. Associate professors teach about eight hours per week. Full professors can negotiate their teaching commitment and usually teach 2–4 courses per year; these take about 4–6 hours per week. They write and administer research grants themselves, but the university does provide financial analysts.

Research networking and interaction

The unit has extensive national, international and industrial collaboration. In addition, the biological physics collaboration is multidisciplinary and involves both theory and experiment. Faculty members have an international presence; they are on international editorial boards and review committees and give presentations at international conferences. As part of collaborative research programmes, the unit's students visit international collaborators and often take postdoctoral positions abroad after graduating. The unit has strong links to the Centre of Excellence in Computational Nanoscience at Aalto University, as one of the unit's groups is affiliated to it. The unit has the healthy view that it is not a competitor to the Centre but rather complements it.

Research infrastructure

The unit can use an excellent in-house cluster computer with about 1,000 cores (Tampere Center for Scientific Computing). An upgrade to this computer has been ordered. The unit also uses the national supercomputer facility of CSC, which amounts to about 1,000–2,000 core-years of computing time per year, and the Jülich Supercomputing Centre, which amounts to about 5,000 core-years per year. The unit also uses other international computer facilities. Locally, it uses standard software, though installing this software on local machines can be a strain. Maintaining state-of-the-art computing facilities is a constant challenge.

Recommendations

The unit appears to be too small and needs to be expanded by filling the current tenure-track position and by finding a replacement for the departing professor. The optimum size would be 5–6 professors. The groups of the unit would benefit from working together to combine resources and tasks. The administrative load on senior researchers and faculty is somewhat burdensome. A reduction in committee duties and reports required by the university would help. In addition, computer system administrators and computer user managers should be hired to handle administrative tasks involving managing the computer systems and users. Currently, these duties are the responsibility of the senior researchers.

4.10 Tampere University of Technology, Optics Laboratory

Overview

The Optics Laboratory at Tampere University of Technology (TUT) consists of three subgroups, which share laboratory space and research infrastructure. The unit is headed by one professor and also comprises one Academy Research Fellow and one senior scientist. In addition, the unit has four postdoctoral researchers and some ten PhD students. In 2011, the unit's total funding was almost EUR 1.29 million, of which EUR 1.072 million came from external sources. The most important external funding sources are the Academy of Finland, national doctoral training programmes and Tekes.

Research profile

The research at the Optics Laboratory covers both fundamental and applied topics in the fields of nonlinear optics and spectroscopic measurement techniques. The Nonlinear Optics group studies fundamental issues of nonlinear optics where one of the goals is to design nanostructured meta-materials. The Nonlinear Fiber Optics group studies nonlinear pulse propagations in waveguides and the Applied Optics group studies industrially relevant optical methods. Taken together, this gives the unit a strong and comprehensive optics research programme.

Research quality

The research quality is very good with several publications in top-level journals. Publications from the unit have received international attention and have been highlighted on the Spotlight on Optics website, in *Nature Photonics* and by the Optical Society of America. Members of the unit are frequently invited as speakers at international conferences and meetings. The unit's research has also led to several patent applications.

Research environment

An important part of the research environment at TUT is the Optoelectronics Research Centre (ORC). The unit's interaction with the ORC is important, as it creates necessary infrastructure. The administrative load and internal regulations at TUT are extensive, as at many other universities, and there is limited support personnel. Consequently, a lot of reporting and planning duties have to be covered by the scientists themselves. The head of the unit is presently the Dean of the Faculty. During the ongoing changes at TUT, these duties take up a significant proportion of his time, which is time away from the unit. This is particularly troublesome since he is the only professor at the unit. On the positive side, both TUT and the unit are able to recruit good students.

Research networking and interaction

The unit has high international visibility, as indicated by a very large number of memberships in programme and advisory committees for international conferences and in editorial boards for scientific journals by members of the unit. The active international engagement of the unit creates considerable insight and networks in nonlinear optics, which can be used to both assess scientific questions and create networks and collaborations. The unit also has an excellent and active network within Finland and collaborates with several groups both at universities and in industry.

Research infrastructure

The unit's infrastructure mainly consists of lasers and at present the situation appears to be good, with a relatively large number of different laser set-ups. The unit also has access to instruments jointly acquired by several laboratories at TUT, including a spectroscopic ellipsometer, a profilometer and a scanning electron microscope. For nanofabricated samples, the unit has to rely on external sources, and, at present, most structures come from the University of Eastern Finland. Also the unit's computational resources appear to be good.

Recommendations

The Optics Laboratory is a successful unit with a high scientific level and a very good production of high-quality publications. In order to secure continued high-level activities, another full professor chair should to be created. The position could preferably be in nonlinear fibre optics. TUT would benefit from increasing the administrative support system for the unit's scientists.

4.11 Tampere University of Technology, Optoelectronics Research Centre

Overview

The Optoelectronics Research Centre (ORC) of Tampere University of Technology (TUT) is a large, very well-equipped and extremely well-organised unit that covers a wide range of optoelectronics research themes in a well-integrated manner. The ORC vision is to: (i) conduct basic studies of novel materials and related technologies; (ii) develop new photonic devices and technologies for device fabrication; and (iii) transfer the know-how to industry. To achieve this, the unit has assembled a fairly unique combination of tools covering compound semiconductors fabrication, nonlinear optics, surface science and nanotechnology. The ORC includes five professors (one of them a FiDiPro Professor), one adjunct professor, 13 postdoctoral researchers, and some 25 PhD students on average. The unit's funding has grown from EUR 4.8 million in 2007 to EUR 5.8 million in 2011, with approximately 39 per cent of this being core funding and the rest coming from external sources. Over the assessment period, the unit received some EUR 4.5 million from the Academy of Finland, some EUR 5 million from Tekes, some EUR 2 million from the EU and some EUR 1 million from doctoral programmes. Purely industrial funding accounted for EUR 0.27 million, and the unit also received some EUR 3 million from other public sources (Centre for Economic Development, Transport and the Environment) and some EUR 0.5 million from other foreign sources.

Research profile

The Ultrafast and Intense Optics research group of the unit covers activities spanning from the development of fibre lasers to semiconductor disk lasers and the study of few-cycles optics. Particularly notable appears to be the development and commercialisation of femtosecond fibre lasers using semiconductor saturable absorbers developed within the unit. The strategy for the future research in this area includes fibre sources, semiconductor disk lasers, as well as extreme nonlinear optics, and carrier-envelope phase stabilisation with a view to opening a way suitable for an unprecedented level of temporal control and attosecond physics.

The Semiconductor Technology and Nanophotonics groups cover a broad range of activities spanning from the use of molecular beam epitaxy (MBE) for the development of a wide range of optoelectronic devices to the development of nanoimprint lithography (NIL) and laser processing methods as enabling tools, for example for the fabrication of nanostructures for nanoplasmonics, metamaterials and photonic crystals. The current emphasis in terms of materials research is on epitaxy of highly-mismatched alloys, site-controlled epitaxy of quantum dot systems and fabrication of high-impact optoelectronic devices such as high-efficiency solar cells. The strategy aims to advance the fundamental limits of the epitaxial technologies, to develop a new class of semiconductor materials, and apply these materials in demonstrating novel functional devices.

The Surface Science Laboratory has a long history at TUT but only joined the unit in 2011. This research group studies the physical and chemical phenomena at surfaces and interfaces of biomaterials, nanostructured materials and metal alloys with mainly scanning probe and electron spectroscopy techniques. The research has both a fundamental and an applied character and aims to understand the relations between surface electron structure and morphology and reactivity on the nanometre and atomic scale.

Research quality

The research quality of the unit is outstandingly high. The scientific output is top-quality in terms of papers and active collaborations across the spectrum of the research teams and levels. The unit's publications are in well-established refereed journals with an international profile. The groups' visibility is excellent both at national and international level, with more than 230 papers in refereed journals, several tens of invited journals in international conferences, as well as coordination of and participation in a large number of European projects.

The unit has generated five spin-offs, has licensed technology to Nanofoot Finland and has played a role in professional organisations such as Photonics 21 and EPIC (European Photonics Industry Consortium). The unit has also played an active role in Laser Competence Centre Finland and the industry-driven national cluster in photonics, Photonics Finland. The unit appears to optimally leverage its diverse and vibrant research environment (well over critical mass), so as to ensure both breadth and depth in the research covered.

Research environment

The unit provides and operates a top-quality environment. The different activities are well interconnected, and the unit is well integrated within the TUT Faculty of Science and Environmental Engineering and contributes to teaching with a manageable load of about 2–4 courses per year. The unit has also been recognised at local level (TUT) as one of the three leading-edge fields of research following an internal research assessment exercise (TUT-RAE), which rated the relevant aspects of research. The unit is well linked with the rest of the university and with a variety of companies nearby, as well as with larger companies at national level, including the spin-offs from the unit itself.

The unit has a commendable culture of equipment sharing that enables the maintenance of a large capital equipment basis, and which in turn enhances the research capacity of the unit at large. The unit receives appropriate support from the university and gives an outstanding contribution to attracting a large cohort of prospective students, only a fraction of whom can be accepted, thus enabling selectivity of the highest levels (only 20% of applicants accepted). The unit has nevertheless strongly contributed to the academic output with 19 students achieving their degrees during the evaluation period, and then moving to academia in Finland and abroad.

Research networking and interaction

The unit's networking is excellent, both within and outside the national boundaries. It has acted both as a coordinator and as a participant in several European grants, thus ensuring a continuous stream of funding and high-level scientific interactions. The unit also has a large network of industrial collaboration with a related sizeable impact on its finances, either in the form of pure industrial funding, funding from Tekes, or in other forms. The unit demonstrates an excellent ability to both maintain established collaborations and forge new ones. One collaboration that was noted as particularly successful is the one with the University of Eastern Finland in Joensuu regarding e-beam lithographic patterning of masters for nanoimprint lithography. The Surface Science Laboratory is an active member of the Finnish Synchrotron Radiation Users Organisation (FSRUO), which helps Finnish scientists conduct experiments at European synchrotron radiation facilities.

Research infrastructure

The unit is very well funded in terms of both capital equipment and personnel provisions. In addition to cleanrooms and related micro- and nanofabrication equipment, the unit benefits from a large number of MBE systems that allow for a variety of projects and research directions. The unit appreciates that MBE is a relatively expensive growth technique and has identified high-efficiency PV cells (e.g. for solar concentrator applications) as one target application for the future, and has started developing both a research programme and an infrastructure development plan in this direction. The nanoimprint lithography activity relies on e-beam lithography for master fabrication that is done in collaboration with the UEF in Joensuu.

While this appears to be a very good example of domestic collaboration, the unit should consider the possibility of acquiring a similar lithographic tool so as to facilitate the time from design to implementation of photonic structures. The Surface Science Laboratory has an excellent home laboratory with two electron spectrometers, a variable-temperature scanning tunnelling microscope and a supersonic molecular beam surface-scattering system apparatus that is unique in Finland. The group also spends some weeks at synchrotron radiation laboratories every year.

Recommendations

While it already has a strong network of collaborations in place, the Optoelectronics Research Centre might want to consider liaising at a high level with other foreign optoelectronics centres, so as to build critical mass and ensure complementary action, as well as potentially leverage European funding at a level above the one of usual tools (medium or large collaborative projects, or Marie Curie Actions), such as "Flagship" or similar, following identification of strategic objectives for the European optoelectronics industry. This will probably need also a higher level of involvement with European corporations active in optoelectronics. The emphasis on MBE growth is currently well justified, but the evaluation panel recommends that this be reviewed regularly at two-year intervals, to assess its viability in a rapidly changing economic and technological environment.

4.12 University of Eastern Finland, Department of Applied Physics

Overview

The Department of Applied Physics of the University of Eastern Finland (UEF) has a history of 40 years but has considerably increased in the last ten years. The Department's educational and research activities focus on computational, environmental and medical physics. In 2010, the Department was established as a joint unit with the Department of Physics and Mathematics on the Joensuu Campus. However, since 2011, the Department has again had an independent status. The multidisciplinary activities are led by eleven professors, one professorship being shared with Kuopio University Hospital and two professorships in aerosol physics with the Finnish Meteorological Institute (FMI). Within the eleven professors, three work in part-time at the Department. The annual budget (2012) of the Department is EUR 7.4 million, of which core funding accounts for EUR 2.2 million (30%), other budgetary funding (e.g. spearhead projects) for EUR 0.8 million, and external funding for EUR 4.4 million (59%).

Research profile

The research carried out in the fields of computational, environmental and medical physics addresses complex problems of the modern society, such as those related to climate change and population ageing, which are highly relevant issues in modern society. A particular role is played by computational physics, which not only provides innovative tools, but also stimulates and facilitates new ideas and developments. Medical physics takes optimal advantage of the collaboration with hospitals, bringing the physics perspective and the innovative applications of physical tools to medical research. The unit has well-established experience in musculoskeletal research. The success of the atmospheric physics group is rooted particularly in the international Finnish dominance in the field of experimental and theoretical aerosol and cloud microphysics research.

Research quality

The unit has reached high standards within each research field, as highlighted by the fact that it has received a status as Centre of Excellence both in environmental physics and computational physics as well as a prestigious ERC starting grant in medical physics for one young researcher. The research output is in general of a very high level. The unit publishes papers in esteemed international journals. Over the last years, the number of papers and citations has been growing considerably. The computational physics group is a world leader particularly in connection with applications in electrical impedance tomography and in statistical methods in inverse problems.

Research environment

The success of the unit's research is related to the present research environment creating optimal conditions for teamwork. The good teamwork within the unit is attractive to graduate students and postdoctoral researchers. The unit actively takes part in joint national training programmes for graduate students. In some cases, the PhD projects connected to industry have lasted up to six years. This is not in line with the average European duration. So far, the PhD graduates have preferentially found positions in research. This reinforces the network and is beneficial for the further development of the unit. As for career policy, the unit has recently initiated a tenure-track system, the efficiency of which will have to be demonstrated.

Each year, there is an internal evaluation of the research groups of the unit, which stimulates improvement and enhancement of productive collaboration schemes. Particular effort is devoted to growing competence in research, to supporting young researchers in their careers and to opening international calls. These fields have great potential. In particular in its future plans, the unit suggests innovative methods based on basic physics research and even stronger collaboration between the research groups.

Research networking and interaction

As far as collaborations are concerned, it is important to stress that PhD education and the Centres of Excellence promote and facilitate both national and international collaboration. In the present case, the multidisciplinary nature of the unit's research has inherently a collaborative approach and a tendency to exploit the intellectual synergies well. These collaborations are well established and have been expanding over the years. Even at the level of graduate students, the unit organises research periods abroad. In addition, joint projects with industrial funding are carried out, often involving graduate students and Tekes funding, in which industrial contribution is a prerequisite. Part-time appointments with other institutions enhance external collaboration, although it is important to avoid possible reduction in interaction with students and colleagues. All in all, the research of the unit has high, direct societal impact.

Research infrastructure

The unit has quite good instrumental and laboratory infrastructure, and efforts are being made to realise new equipment essential to maintaining or enhancing the innovative character of the research. Presently, a lot of competence is carried by non-permanent personnel. In fact, postdoctoral researchers and students take responsibility for operating and improving laboratory facilities. The operational costs of the laboratories rely considerably on the use of spare funding from overheads of research grants. A scheme more sustainable in a strategic sense would be desirable.

Recommendations

Efficiency could be improved in the long term with the presence of permanent technical support personnel. It is important to assure a stable operation of the infrastructure and equipment and the necessary upgrades dictated by the progress in the field. Because of the educational and administrative load on senior professors, it would be important to provide the possibility of a sufficient number of experienced postdoctoral researchers to support the research training of graduate students.

4.13 University of Eastern Finland, Laboratory of Photonics

Overview

The Laboratory of Photonics of the Department of Physics and Mathematics at the University of Eastern Finland (UEF) is a medium-sized, well-equipped and well-organised unit whose research activity is dedicated to photonics. The unit has a staff of some 85 (incl. technical staff and part-time teachers). The unit includes six professors (plus 50% of a FiDiPro Professor shared with Aalto University) and one additional part-time professor. In the Department of Physics and Mathematics as a whole in 2011, there were five PhD and 13 MSc degrees oriented to physics research and three PhD and 15 MSc degrees oriented to other fields. The unit attracts some EUR 3 million annually in core funding, and a similar amount of external funding. The unit hosts the only "industrial" e-beam lithography system in Finland, which makes it a natural partner for other units active in nanophotonics, such as the Optoelectronics Research Centre at Tampere University of Technology and the photonics unit at Aalto University.

Research profile

The vision of the unit is to carry out research in a variety of topics under the photonics umbrella, which spans from design, fabrication and application of micro-optics and nanophotonics to the use of nanostructured surfaces in biophotonics, to growth and spectroscopy of a variety of materials (incl. a variety of nanocarbons), to modification of surface properties with femtosecond laser ablation, and the study of light sources. The unit has a long-standing tradition in the fabrication and development of holographic structures, which has more recently evolved into the fabrication and characterisation of replicated optics, including antireflection and dirt-repellent surfaces. The unit is also very active in the fabrication of nanocarbon materials via chemical vapour deposition (CVD) techniques, and has developed both nanographites and some unique nanodiamond tips that can be assembled on scanning probe cantilevers thanks to appropriate micromanipulation. Another activity of the unit is the enhancement of fluorescence thanks to nanostructures with applications to diagnostics. Another strand of activity relates to the deposition of materials and nanostructuring via femtosecond laser ablation. This is used for making decorative markings, for controlling hydrophobicity, biocompatibility, etc. The unit has also started work on metamaterials, and has adopted an approach based on the utilisation of DNA crystals.

Research quality

The research quality of the unit is good and commensurate to the size of the unit. During the evaluation period, the unit produced a remarkable output of some 80 papers in refereed journals. The educational output is also good, with the only difficulty being how to attract a larger number of students. This problem does not appear to be linked to the quality of the research and teaching at Joensuu, but possibly to the specific location of the university in a region with a relatively low population density. The unit has a good track record in technology transfer and the creation of spin-offs. This ability and inclination to technology transfer is one of the strengths of the unit that stems directly from the significant success in maintaining and operating nanofabrication (e-beam lithography) and material growth and manipulation equipment very effectively.

Research environment

The unit benefits from substantial support from the UEF in the form of core funding and administrative support for preparing EU grant proposals. This is one of the few units that have a policy of compulsory international secondments for their PhD students. The unit is also very active in the organisation of international summer schools. Students do not teach formally but they help with demonstrations. The unit contributes to education in photonics via a physics Master's degree programme focused on photonics, an international Master's degree programme and two Erasmus Mundus Master's degree programmes (Optics in Science and Technology, Colour in Informatics and Media and Technology).

UEF-Joensuu is also the coordinator of the national graduate school for modern optics and photonics and contributes to approximately half of all the graduated PhDs from the school. Five students obtained their PhD degrees from UEF-Joensuu in 2011. Of the students graduating from Joensuu, about one-third go on to work in companies, about one-third in Finnish universities, one-fourth abroad and the rest in other research institutes. However, there is a relatively limited number of applicants at BSc level, with only 30–40 students starting each year, and with only half of these completing a degree in physics and the others graduating from other faculties.

Research networking

The unit has excellent networking interactions at all levels, starting from PhD students. There are strong interactions with the Optoelectronics Research Centre (ORC) at Tampere University of Technology (TUT) and with Aalto University, and several interactions at international level, including Japan, Singapore, the US, China, India, Brazil, Germany, France, Spain, Italy, the UK, Sweden and Russia. There is also significant interaction with industry, especially with spin-offs that have originated from the UEF. Collaborations are significantly multidisciplinary by nature, and include chemistry, medical physics, diagnostics, biology, etc. The unit has a strong link to the ORC at TUT regarding e-beam lithographic patterning of masters for nanoimprint lithography, although this link may weaken in the future if the ORC acquires its own e-beam lithography system.

Research infrastructures

The unit is generally well funded. Having the only Finnish "industrial" e-beam machine is obviously an element of strength and the UEF recognises the importance of this activity with significant core funding. The unit also benefits from growth facilities for its nanocarbon work, although some further investment in this area would be needed to capitalise on some of the advances in this area, for example a micromanipulator to help with the positioning of the diamond tips on appropriate cantilevers. The unit appears to have a strategy in place for the acquisition of the necessary funds to acquire this facility. In the longer term, the unit will need to replace the main piece of capital equipment, the e-beam lithography system, with more up-to-date lithographic tools, either e-beam, focused-ion beam, or scanning-probe-based tools.

Recommendations

The unit should elaborate a detailed financial model for the replacement of the e-beam system, even though there is no urgent need for replacement. The unit is already active in terms of outreach programmes to try to increase the number of students. The unit's outreach effort should be further increased, if at all possible. Advertising educational activities at Joensuu in scientific magazines (*New Scientist*, *Physics World*, *Physics Today*, etc.) might provide an effective channel to this effect.

4.14 University of Helsinki, Division of Atmospheric Sciences

Overview

The Division of Atmospheric Sciences of the Department of Physics at the University of Helsinki (UH) is a rather large unit that, during the evaluation period, had on average four professors, six senior researchers and twelve postdoctoral researchers. Some 40 postgraduate students and researchers were employed at any time. These numbers fluctuated mainly due to the fact that 70–80 per cent of the funding comes from competitive sources. From the very beginning, the Division was concentrated on the investigation of micro-scale processes relevant to aerosol formation in the atmosphere. Aerosols interact with radiation and are the necessary prerequisite for the formation of clouds. These processes were little understood in the past and even today, leading to the biggest uncertainties in climate simulations. The Division has led the progress in this field with theoretical, laboratory and field studies. Today, it is the world-leading research group in aerosol formation.

Research profile

The unit's research is concentrated on laboratory and field observations, both performed at an outstanding level of sophistication, and on high-quality theoretical and computer (numerical simulations) studies. The main topics are: (i) formation and growth mechanisms of atmospheric aerosols as well as aerosol and air ion dynamics; (ii) the effect of secondary biogenic aerosols on the total aerosol burden; (iii) aerosol-cloud-climate interaction; (iv) air pollution-climate interaction; and (v) relationships between different ecosystems and the atmosphere with specific emphasis on boreal forests. There is a good balance between these topics. Both observational and theoretical work forms the backbone of the highly successful national and international cooperation, where the original results are utilised and put into a wider context. Overall, the research is multidisciplinary and those activities exceeding the core competence are carried out in collaboration with other institutions on national and international levels.

There are continuous comprehensive monitoring activities that are mainly, but not exclusively, based on the comprehensive measurements at SMEAR stations installed across Finland together with a SMART-SMEAR data distribution interface. These have allowed considerable progress in understanding the complex interplay between forest ecosystems and the atmosphere. The development of new instruments, specifically the air ion spectrometer, the particle size magnifier and the Atmospheric Pressure Interface Time-of-Flight Mass Spectrometer, is designed to meet the needs of the core activities of the unit. The unit is also developing next-generation retrieval algorithms for satellite and ground-based remote sensing observations.

Research quality

The quality of the research is outstanding and is internationally highly esteemed. Without a doubt, the unit is the world leader in aerosol nucleation studies, having first observed, then monitored and finally studied theoretically and with computer models the large contribution of newly formed secondary aerosols to total aerosol mass. Having concentrated from the very beginning on the smallest observable scales of aerosol formation, the research is innovative quasi by definition. This is true for all sub-branches of the unit. It starts with instruments of unseen precision first developed in the laboratory (often with contribution by SMEs), then used in the field and for monitoring, and supported by theoretical studies leading to numerical models and parameterisations to be used by the wider community. Most of the best aerosol simulations done in Europe and beyond are at least based on, if not directly developed from, results of the unit. The unit has continuously produced a large number of scientific publications in leading journals. The scientific impact is very high.

Research environment

The unit is the only place in Finland where meteorology can be studied, and it hosts international Master's programmes. This leads to a permanent inflow of highly talented and motivated students forming the reservoir of new PhD students. The excellence of research and research facilities furthers the number and quality of international and national visiting scientists and paves the way to collaboration.

Research networking and interaction

The unit's networking activities are exceptional and impressive. There is indeed global coverage of collaboration with the most advanced research groups, which at the same time are the main competitors. The unit leads and has led a number of important national, EU and international projects and has actively participated in no fewer than 45 EU projects. The UH hosts the iLEAPS Project Office, an IGBP core project, coordinating 13 affiliated international projects with participants from more than 100 countries. Also the Headquarter of the Integrated Carbon Observation System ICOS will be located in Helsinki. The unit is strongly contributing to this activity, in collaboration with the Finnish Meteorological Institute (FMI), with the SMEAR and other monitoring stations.

There are also strong links to industry and two spin-off companies. The main partner is Vaisala Ltd, and about ten other smaller companies cooperate with the unit to mutual benefit. The Centre of Excellence includes the Department of Forest Sciences and the Department of Chemistry at the UH, the University of Eastern Finland and the FMI, which is situated on the same campus and is a main national partner in research and development.

Research infrastructure

The unit operates facilities that are unique in the world. Besides the SMEAR observational stations, which are run by the unit, it operates the Aerosol Particle and the Mass Spectroscopy laboratories. The SMEAR observational stations have been recognised as a Finnish national research infrastructure and belong to three ESFRI programmes. All these facilities are used by national and international collaborators.

Recommendations

The unit has grown considerably in recent years. This poses some threats since the majority of funding comes from competitive sources. Many of the monitoring and laboratory activities require permanent and well-trained personnel, which is hard to maintain with fluctuating funding. It would hence be advisable to increase the percentage of sustained funding. Further, due to the growth, the unit is currently spread over two different buildings. Co-location certainly would improve synergies and the efficiency of research.

4.15 University of Helsinki, Division of Elementary Particle Physics

Overview

The Division of Elementary Particle Physics is one of four divisions in the Department of Physics at the University of Helsinki (UH). Its activities are closely connected to Helsinki Institute of Physics (HIP) and many of the personnel in the Division have joint appointments there. Put together, there are now seven professors, of which one is an Academy Professor. In addition, there are five university lecturers, two Academy Research Fellows and six postdoctoral researchers. Three of the five research programmes of HIP are led by the professors of the Division, and three of the current projects in the programmes are led by professors or other senior personnel of the Division. At the present time, there are around 30 PhD students, and most of them also belong to some HIP research project, although the degrees are granted by the Department. It should be mentioned that the group also has three retired staff members who are still very active both in research and in the interaction with students. Of the Division's total budget, 60 per cent comes from external sources. Among these, the Academy of Finland is the strongest contributor, but many public funds are also made available. On the more technical side, there little support from Tekes.

Research profile

The unit's experimental research is concentrated around the big CMS detector and the smaller TOTEM project at the LHC accelerator at CERN. Previously, the unit also participated in experiments at the collider detector at Fermilab (CDF), an activity that now has come to an end. It also participates in the development of the future CLIC (Compact Linear Collider) linear accelerator, whose realisation is still uncertain.

At the CMS detector, it is the search for the Higgs boson that has generated the greatest interest and excitement. There is increasing evidence that this particle can be seen in the present data, and the next couple of years will most likely settle the issue. The search for supersymmetric particles in the products of the collisions has so far not yielded any results and will therefore be eagerly continued. Such new physics can also show up in decays of B-mesons containing heavy quarks, which is another avenue of research being pursued, so far based on CDF data. In the TOTEM experiment, researchers will measure the differential and total proton-proton cross-section at LHC energies. Although of less fundamental relevance, the outcome will be important for the understanding of the overall physics at this accelerator and give new tests of QCD.

Theoretical research in the unit is closely tied to experimental activity. In addition to fundamental work within the framework of perturbative QCD to explain bound states of quarks, there has also been visible activity in investigating this theory in the strong-coupling limit based on ideas from string theory. This is usually denoted by the acronym AdS/QCD and can also be of importance for the understanding of the quark-gluon plasma under investigation in the ALICE experiment at CERN.

Although the discovery of the Higgs boson will to a large degree complete the Standard Model, the detailed understanding of the electroweak sector and the masses of quarks and leptons will still be missing. For this reason, there is ongoing, theoretical and phenomenological research in particle physics based on supersymmetry, extra dimensions, string theory and extended gauge models. In parallel with these efforts, the unit has a programme in computational field theory based on Monte Carlo simulations. These methods can also be used to investigate technicolour theories, which have the potential to provide a more dynamic understanding of the Higgs mechanism in the electroweak sector.

High-energy particle physics has direct implications for cosmology just after the Big Bang. The unit has pursued this line of research for a long time. Not only theoretical work, but also data analysis of the cosmic microwave background (CMB) radiation has been a visible activity. In recent years, this has been concentrated on data from the Planck satellite.

Research quality

The Division of Elementary Particle Physics is the strongest and most visible of its kind in the Nordic countries. It is the only unit in the region where theoretical and experimental research are closely integrated. Also on the international scale, it is highly regarded and has for a long time been trend-setting. In particular, it was one of the first units that saw the merging of modern cosmology and high-energy physics. It has been a key player in this direction ever since.

The PhD students coming out of the unit are sought after by other institutions and several of them have started their own careers abroad. In recent years, the professors of the unit have received several prizes and many of them are members in Nordic and international boards. Recent and ongoing retirements could change this positive development in a more negative direction. It is therefore important that necessary funding is secured to fill these vacancies, since the number of permanent positions is very low. The evaluation panel would encourage the hiring of additional foreign nationals in more permanent positions in order to broaden the international profile of the unit.

Research environment

Both the Department of Physics and Helsinki Institute of Physics (HIP) are located within the same premises on the new and modern Kumpula Campus. The unit offers advanced courses in particle physics and cosmology that are directed towards the current, ongoing research. The experimental activities take place at CERN. Instruments and detectors are built and tested on-campus in the Detector Laboratory, which is a joint facility with HIP.

The big overlap in activities and personnel between a university physics division and research institute is an unusual constellation on the international scene. It creates a very diverse and creative atmosphere that provides the best possible environment for education and research. Based on the selection of modern and advanced courses, the students get an excellent background to starting their thesis work in experimental and theoretical research. This teaching is supplemented with smaller seminars where specialised topics are discussed, supplemented with more general colloquia on a regular basis. In contrast to other physics groups in the country, this unit has seen little or no decline in the last years in the number of students wanting to get a degree. Recently, some efforts have been made to move some parts of the particle physics teaching to earlier slots in the curriculum. This can be achieved by organising training courses and involving the Detector Laboratory in the Master's-level laboratory exercises.

The unit has a large number of postdoctoral researchers and visitors from abroad. This influx of foreign nationals creates a very fertile research environment. This collaboration is mostly funded by external resources and a reduction in this visitor programme should be avoided in the coming years. Since the unit has rather few permanent positions and competitive career paths to young talented researchers cannot be offered, this more temporary component of the staff is very important.

Research networking and interaction

The area of elementary particle physics has always been very international, with close collaboration between countries. On the experimental side, this is now concentrated and organised around CERN, where the unit is participating in the large-scale experiment taking place at the CMS detector. In this connection, there are regularly organised meetings, conferences and schools.

The same kind of networking takes place in cosmology, where the unit is an active member in the Planck satellite collaboration dedicated to the detailed investigation of CMB radiation. The unit is also involved in the next big cosmology experiment, Euclid, which will keep the unit in the forefront of research also in the future. A corresponding networking takes place also within theoretical particle physics. In addition to this international collaboration, all members of the unit are or have been active in Nordic networks supported by all countries in this region. This activity includes conferences and winter and summer schools, which provide extra training for the students and younger researchers.

Research infrastructure

By its very nature, high-energy physics experiments are today done at international installations such as the LHC accelerator at CERN. But much of the technical work is done in member countries. At the UH, an important part of the infrastructure is the Detector Laboratory, which is a joint facility of HIP and the unit. The laboratory provides premises, equipment and know-how for the R&D and construction of gaseous or semiconductor detectors for international particle physics experiments. It consists of a main laboratory and three cleanrooms (two class 1,000 and one class 100). Additionally, the unit has unique experimental installations for pulsed magnetic fields up to 45 T and a SQUID (superconducting quantum interference device) magnetometer. Additional resources are needed for the optimal operation and maintenance of this infrastructure.

For data analysis and Monte Carlo simulations of quantum field theory, the unit makes use of the computing power of CSC. In parallel to this comes access to the worldwide LHC computing grid at the Tier-2 level established for the CMS engagement at CERN. This computer infrastructure will continue to be crucial in the coming years for the function of the whole unit and should be maintained at the same level or strengthened if additional resources are made available.

Recommendations

The unit should continue its programme in theoretical and experimental high-energy physics with a clear component in the direction of modern cosmology. Funding for this collaboration should be secured for the coming years so as to allow for planning over longer periods. A closer integration between the experimental and theoretical activities will be obtained by joining in a new Centre of Excellence. More career paths should be opened up for younger, talented researchers and with tenure-track possibilities. The staff should be strengthened by hiring more foreign nationals in permanent positions.

4.16 University of Helsinki, Division of Materials Physics

Overview

The Division of Materials Physics in the Department of Physics at the University of Helsinki (UH) is a large unit. It has eight professors, 21 PhD researchers, 26 postgraduate students, 14 graduate students and ten technical staff. In 2011, the total funding of the unit was EUR 5.226 million, of which EUR 2.648 million comes from external sources. By far the largest funding source is the Academy of Finland, followed by the national doctoral training programmes and Tekes. The unit also has some funding from the EU.

Research profile

The unit covers several important topics in both basic and applied materials physics, which also in part cover biological and soft-matter physics, nanoscience and nanotechnology, ion beam physics, electronics, medical physics and materials science. The basis for the truly interdisciplinary research is an excellent knowledge of fundamental physical characterisation techniques and their application in applied science. Of considerable importance is the unit's good research infrastructure, in particular for the ion beam and X-ray studies. The unit also demonstrates a first-class ability to test new ideas and go into new research fields. One example is the applications of X-ray scattering in biology, another the development of test experiments in medical physics. The unit also has a strong and successful computational programme.

Research quality

The unit's research quality is excellent and of the highest international standards. Members of the unit regularly publish in top-level journals and receive personal invitations to international conferences and workshops. The excellent quality of the unit is also shown by the large number of prizes, commissions of trust, etc. given to the scientists. Both the in-house and the synchrotron-radiation-based X-ray studies are truly innovative and well known internationally. The ion beam studies are based on excellent infrastructure support.

Research environment

The research environment at the UH is excellent. The university attracts good students and the unit has developed good contacts with other research groups both at the UH and at other academic institutions in the Helsinki area.

Research networking and interaction

The unit has a large and well-functioning network both nationally and internationally. The unit also has well-established contacts with large international laboratories such as ESRF, CERN and DESY (Deutsches Elektronen-Synchrotron). Medical physics is carried out in collaboration with Helsinki University Hospital, VTT Technical Research Centre of Finland and the Radiation Metrology Laboratory of the Radiation and Nuclear Safety Authority Finland, STUK. The unit is also part of the BNCTMI (Boron Neutron Capture Therapy and Medical Imaging) collaboration. The nanoscience research activities involve collaborations with several world-leading departments. Researchers from the unit often spend time at leading international centres, for example ESRF, Harvard Medical School, CERN and FZ Jülich.

Research infrastructure

The unit has access to excellent research infrastructure. The ion beam work is done with a 5 MV tandem accelerator with five beam lines and a 500 kV accelerator with two beam lines. The X-ray studies are done with two modern SAXS/WAXS (Small/Wide Angle X-Ray Scattering) facilities with area detectors and X-ray micro-tomography. An impressive development is the micro-focus X-ray tube and the Pilatus detector. This is unique equipment that allows studies from the nanometre to the micrometre range. Synchrotron radiation experiments are done at ESRF, France, Spring-8, Japan, Advance Photon Source (APS), USA, and DESY, Germany.

The unit also has a UHV STM/AFM (Ultra-High Vacuum Scanning Tunnelling/Atomic Force) microscope, Auger Electron Spectroscopy (AES) and Low-Energy Electron **Diffraction** (LEED) for surface characterisation. Computer resources are available both at the Department of Physics and through the national FGTI cluster. The scientists also utilise CSC, the national IT centre. The unit also has access to Helsinki University Hospital for medical imaging. The BNCT project is carried out at the reactor in Espoo.

Recommendations

The Academy of Finland and other funding agencies should continue and if possible increase the financial support to this excellent unit. It should also be noted that part of the research depends critically on Finland's engagement in international and European research infrastructures, such as ESRF, ISIS and CERN. The competence and excellence of the unit also motivates a renewed discussion in Finland related to the recent development of free-electron lasers.

4.17 University of Helsinki and Finnish Meteorological Institute, Kumpula Space Centre

Overview

The Kumpula Space Centre was founded in 2006, just before the evaluation period 2007–2011, with the goal of coordinating the space-research-related activities in Helsinki: space physics and technology, astronomy and Earth observation. This evaluation targets the space physics research at the Finnish Meteorological Institute (FMI, about 80% of the space physics FTEs) and at the Department of Physics of the University of Helsinki (UH, about 20% of the FTEs). The Kumpula Space Centre acts as a cooperation umbrella for these fields. In January 2012, the School of Electrical Engineering of Aalto University joined the Centre. Hence, the evaluation covers the space physics groups at the UH and the FMI, both physically located in close spatial vicinity on the UH Kumpula Campus.

By the end of 2011, the unit's space physics personnel consisted of two professors, 43 senior and postdoctoral researchers at the PhD level, six PhD students at the UH and five other academic staff with an MSc degree, as well as seven assisting, administrative and technical staff plus Master's and PhD student project support. Ten Master's theses were completed and eight doctorates were defended over the evaluation period.

The funding of the unit's space physics projects has mainly and increasingly been provided by Tekes. However, most (at present 90%) of the technology-oriented Tekes funding is used for industry contracts. It pays, for example, for the SIXS instrument (Solar Intensity and particle X-ray Spectrometer), a Finnish contribution to the BepiColombo ESA mission under preparation, which is planned to be launched in 2015 for a flight to Mercury. The second most important source of funding is the Academy of Finland. In addition, there is an increasing amount of EU funding, for instance for space-weather-oriented projects, space exploration and space transportation, such as for the Electric Sail project, originating from the FMI. The FMI has also successfully received funding with a large proposal to the European Research Council. At the same time, however, the relative proportion of core funding is decreasing, and presently covers 15 per cent of the unit's finances.

Research profile

The unit provides a holistic approach to space physics. It covers the whole range from innovative scientific ideas to the design of their implementation and, finally, to the assembly of instruments. Together, the unit's groups at the FMI and the UH develop innovative solutions of space-related problems such as solar sails. They carry out space observations in the planetary system. They also analyse measurements, carried out on board spacecraft, and develop theoretical approaches as well as numerical simulation models for the solution of space physics problems.

Research quality

The scientific output of the unit, its contribution of innovative ideas and its impact on the development of new space technologies are all extraordinary high. The unit is guided by a sustainable and long-lasting strategy, which is creatively brought to live and success by highly motivated researchers. Excellent, internationally recognised research results are obtained by using relatively limited resources in an efficient and goal-oriented way as well as concentrated action.

Research environment

The research environment of the unit is very good, especially thanks to the close involvement of the FMI and its laboratories and workshop capacities in the unit. This is favourably combined with the UH part of the unit and its challenges of each year facing a new generation of research-interested young people.

Research networking and interaction

The unit is well integrated in the international, European and transatlantic space research community, where, if compared to the Finnish population, for instance, it has an over-proportional role in terms of science and technology as well as by personal representation in committees and organizations. Finnish space scientists are well known in international networks, they are invited to boards, lectures and guest stays, and foreign scientists like to visit the unit for collaborative work. They are also awarded leading positions in international organisations, prizes and honours. As a result, excellent PhD students are successfully recruited and, after 4–5 years, promoted to academic positions in Finland or abroad.

Research infrastructure

The FMI is involved in maintaining and operating the Magnetometers – Ionospheric Radars – All-sky Cameras Large Experiment (MIRACLE), which is a two-dimensional instrument network constructed for mesoscale studies of auroral electrodynamics. It also runs the laboratory for space instrument calibration and testing.

Recommendations

The Kumpula Space Centre, now extended through the inclusion of the corresponding, newly formed group at Aalto University, must maintain and extend its high-level involvement in modern space research, since it is of crucial importance as a founding block for Finland's involvement in technology-relevant space research. However, the continuation and further improvement of the unit's outstandingly efficient and successful research and education along the lines of its well-thought-out strategy needs further action in order to secure a permanent flow of funding. Otherwise, the unit runs the risk of losing its momentum. Since core funding plays an increasingly smaller role, and in spite of the large number of successful proposals to funding agencies in Finland and Europe, the dependence on an unreliable flow of third-party funding will increase. Nevertheless, in order to stabilise the research and the long-term commitment to space experiments, high-level political decisions are perhaps needed in favour of a stabilisation of the excellent contributions of Finnish physics to space science in the future. At the institutional level, the establishment of more permanent positions, including the re-filling of the professorship lost in 2010, seems to be necessary in order to maintain the accumulated Finnish expertise and competence in space physics.

4.18 University of Jyväskylä, Materials Physics

Overview

The Materials Physics unit of the University of Jyväskylä (UH) belongs to the Department of Physics in the Faculty of Mathematics and Science and forms the physics part of the Nanoscience Center (NSC), a multidisciplinary activity together with chemistry and biology. The NSC was established just before the beginning of the evaluation period. The research staff of the Materials Physics unit include six professors, ten senior researchers, nine postdoctoral researchers and approximately 32 PhD students.

A little less than half of the unit's budget comes from core funding. About half of the external funding is provided by the Academy of Finland and roughly a quarter by industry. The rest of the external funding is obtained from Tekes in addition to other Finnish and EU programmes.

Research profile

There are three different main directions of research in the unit: experimental nanophysics; theoretical nanophysics and computational nanoscience; and soft condensed matter and statistical physics. The experimental groups work on electrical and thermal transport of nanostructures, such as carbon nanotubes, low-dimensional nanobeams and -membranes, and superconducting nanowires. The experimental activities also include development of devices for chemical sensoring and radiation detector applications. The theory groups investigate low-dimensional systems, such as quantum wires and quantum dots, and graphene ribbons as well as gold nanoclusters, and non-equilibrium nanosystems. The soft condensed matter activities include DNA electronics, X-ray tomography and 3D image analysis. Overall, it appears that the variety of topics and the concentration of a few subjects are well balanced and quite appropriate given the size of the unit.

Research quality

The unit shows both high research output and high quality. The differences between the groups of the unit are rather small in this respect. The rate of publication is certainly better than the average and many of the publications appear in good journals. A detailed look at the unit's publications reveals that a certain proportion of publications are quite original and internationally leading. Invited talks at international conferences underline the impact of the research done in the unit. The time to complete a PhD thesis is on average 4.6 years but varies between 3 and 13 years.

Research environment

The research environment is generally good and it appears that the unit is well organised and structured. The unit has a common strategy, which is embedded in the planning at the department level. It has also established an international Master's programme in order to recruit internationally. The advanced courses are given in English. At present, the number of foreign students within this programme is still rather low, and the visibility of the programme needs to be enhanced to meet its goal. The teaching load on the professor and senior scientist level is moderate and does not negatively impact the research capabilities. However, administrative work associated with applying for certain type of external funding has increased quite substantially and it appears that the central administration of the university does not provide sufficient support in this respect.

Research networking and interaction

The Nanoscience Center in particular stimulates the exchange and interactions with the neighbouring departments in chemistry and biology. Moreover, there are common funding applications with biology in planning that will strengthen the interdisciplinary aspects of the research at the NSC. Given the visitors and collaborative projects, the unit seems well connected on a national and international level. More than 50 per cent of all publications include either a domestic or a foreign co-author.

Research infrastructure

The unit has developed an impressive research infrastructure, including a modern 200-square-metre class 100 cleanroom with major micro- and nanofabrication tools, such as e-beam lithography. The low-temperature facilities include six dilution refrigerators and one ADR (adiabatic demagnetisation refrigerator). In addition to developing and operating instruments for 3D micro- and nanotomography, the unit has several scanning-force and near-field microscopes. The infrastructure of the unit appears to be in excellent shape. The unit also gives external users access to their infrastructure.

Recommendations

The unit should maintain its high-quality research and perhaps consider further strengthening the collaboration with biology. The unit would greatly benefit from steady funding for their important cleanroom infrastructure. The fragmented project funding does not guarantee maintaining and further developing the top level of this facility. The support for the cleanroom should come either from the university or from national funding. The heavy administrative work associated with applying for EU grants rests largely on the shoulders of the group leader. The UJ should implement an efficient support system for such applications and for handling the resulting grants. This would not only free the researchers from this type of work but also professionalise the applications and therefore increase success rates. The evaluation panel further recommends that the unit consider establishing a monitoring and mentoring system for PhD theses to avoid overly long durations.

4.19 University of Jyväskylä, Nuclear and Accelerator-Based Physics

Overview

The Nuclear and Accelerator-Based Physics unit is responsible of the activity at the corresponding laboratory facility located in the University of Jyväskylä (UH) Department of Physics in the Faculty of Mathematics and Science. The unit is the only international infrastructure in Finland, the only one in this field in the Nordic countries. The laboratory, which is an integral part of the Department of Physics, has been recognised by the EU as one of the large-scale facilities in Europe. It is a Centre of Excellence of the Academy of Finland (since 2000) and also includes the nuclear theory activities of the Department. The laboratory focuses on basic nuclear science, on cutting-edge technical developments and on applications, among them those conducted by the Materials Physics unit. The unit is also strongly linked to the particle physics unit, particularly in the detector development activity.

The unit is rather large including on average six professors, 15 senior researchers, eight postdoctoral researchers and 31 doctoral students. The unit's budget increased during the evaluation period 2007–2011. In 2007, the budget was EUR 6 million, of which EUR 3.4 million was core funding and the rest external funding. In 2011, the budget was EUR 8.2 million, of which EUR 4.6 million was core funding and the rest external funding. Of the annual budget, 55 per cent goes to salaries, 22 per cent to rents and infrastructure, and 13 per cent to instruments and material.

Research profile

The unit successfully carries out both basic and applied nuclear research using accelerators providing ion beams of different species and energies and complex apparatuses for ion separators and particle and gamma detection. The activity in basic research, which is the dominant one, addresses key questions of modern nuclear physics related to the understanding of the complex nuclear system far from stability as well as nucleosynthesis. In this context, the unit has focused on rare-isotope beam science and on the nuclear structure study of super-heavy elements and heavy proton-drip-line nuclei. The experimental tools for this research include cutting-edge technologies and were constructed with the aim of achieving unique results. Some contribution to nuclear reaction studies is also given in connection with fusion and fission dynamics. The small group working on the ALICE CERN experiment is to some extent connected to this heavy-ion reaction activity at the unit.

The research concerning material characterisation and modification uses nuclear techniques with dedicated set-ups in the laboratory. The unit also contributes considerably to complex technical developments for CERN-ISOLDE (Isotope Separator On Line-Detector) and has started to contribute to the future research programmes at the larger-scale ESFRI facility FAIR.

Research quality

The research quality of the unit has always been extremely high. An impressive number of results are at the frontier in nuclear physics and published in papers of high impact. In rare-isotope beam science, the unit has pioneered innovative techniques that are also used at CERN-ISOLDE, where a group is also very active. The unit is a leader in precision measurements of ground-state properties and beta decay of rare isotopes, which stringently test modern theory.

The unit is highly internationally recognised for the gamma spectroscopy of proton-rich nuclei, in particular for that of super-heavy elements. A recent outstanding result concerns nuclear isomers in super-heavy elements. The nuclear theory group, including a distinguished scientist, addresses important developments in energy-density functionals for nuclear structure problems, and develops nuclear theory for neutrinoless electron conversion decays.

Research environment

The research environment of the unit creates optimal conditions for efficient teamwork. The teams include several foreign guests and long-visiting graduate students and postdoctoral fellows. The research activity is well organised and efficient. A good proportion of the personnel are foreign nationals.

Very good training is given to graduate students, who in addition to their work on specific experiments generally take active part in operating the accelerators. The graduate students also spend periods abroad as part of their training. The career policies have recently been changed into a tenure-track system and so far the PhD graduates from the unit have found a position either in the research environment or in companies.

Research networking and interaction

The unit's research activity has long been based on international collaboration. International collaborators have also partly contributed to funding and constructing some of the existing apparatuses. Foreign users, particularly graduate students and young researchers, are partly supported by EU funding obtained by the unit thanks to its large-scale facility status. Collaborations and networking have been well established also for the activity concerning applications. The accelerator laboratory has been accredited as a test site for ESA and has won the National Academic Entrepreneurship Competition 2011 for its commercial services. The new cyclotron has a beam line for medical radioisotope production. The groups are proactive in outreach activities to gain public visibility in all research aspects carried out at the unit.

Research infrastructure

This is a research infrastructure of a very high quality. It is very clear that particular effort has been made to maintain these high standards over the years by improving and expanding the available apparatuses. Recently, two new accelerators were installed in the facility, a linear accelerator for materials science applications and a proton accelerator for radioisotope production and for basic research in rare-isotope science. The short- and long-term future programmes of the unit are well planned. They are based on the realisation of more difficult experiments and applications together with some activity contributing to the construction of the larger international ESFRI facility FAIR, via the collaboration with Helsinki Institute of Physics.

Recommendations

For the optimal operation and maintenance of the major instrumentation installed in this international laboratory (the only one in Finland), it is very important to have a funding scheme more stable in time. A rather long-term funding plan is also a key issue when defining new commitments. More career paths should be opened up for younger, talented researchers and with tenure-track possibilities. The evaluation panel also recommends that the unit increase the technical personnel essential to guaranteeing a smooth operation of the accelerators, which presently is heavily dependent on students.

4.20 University of Jyväskylä, High-Energy Physics

Overview

The High-Energy Physics unit is part of the Department of Physics at the University of Jyväskylä (UJ). During the evaluation period, the unit typically had two professors, five senior researchers and a similar number of postdoctoral researchers. During the evaluation period, the unit lost one professor. The number of graduate students has been nearly constant and close to 15 each year. Two-thirds of the budget is core funding, where a significant part comes via Helsinki Institute of Physics (HIP). The dominant part of the external funding comes from the Academy of Finland and the rest from doctoral programmes, the EU and private sources.

Research profile

The research is rather fragmented in roughly three directions. The most active and visible group is focused on heavy-ion collisions at very high energies. Members of the group have participated in the PHENIX (Pioneering High-Energy Nuclear Interaction eXperiment) experiment at the RHIC (Relativistic Heavy Ion Collider) accelerator in Brookhaven. Now, this work is concentrated around the ALICE experimental facility at the LHC accelerator at CERN. These investigations are followed up by an active theory programme based on perturbative QCD and in particular the establishment of accurate nuclear parton distribution functions.

A smaller activity, but clearly visible over a long time, has been the study of neutrino physics and oscillations. This clearly ties up with new physics beyond the Standard Model and becomes more and more important in modern high-energy physics. To some extent, it overlaps with related work within the unit's third research direction on cosmology and astroparticle physics. As the UJ is one of the founding universities, the unit collaborates closely with HIP. This takes place through a theory project led by the heavy-ion and neutrino groups and another led by the cosmology group. There is also a nuclear matter programme, where the ALICE group of the unit forms the experimental part of the HIP ALICE project.

On the experimental side, there is also a small group of very active members with interests in underground, experimental neutrino physics and who are already involved in the EMMA cosmic ray experiment in the Pyhäsalmi mine. They are now also actively involved in the planning – and lobbying – for the LAGUNA experiment and the corresponding detectors to be installed there. Should this new facility be approved, it would be a focusing point for the unit that could play a key role in the construction and running of the facility.

Research quality

The overall quality of the unit's research is good and the research has some impact, but it would most likely improve if the unit could establish a more unified research programme. Among the three research directions within the unit, the most prolific in terms of papers and talks is the theoretical work within heavy-ion collisions. This is good and solid work, but would benefit from more originality. Since it is directed towards a better understanding of the quark-gluon plasma, it largely has little overlap with the work done in the rest of the unit.

Research environment

The unit has an active visitor programme with a corresponding series of seminars.

But again, due to the fragmented interests in the unit, this part of the research environment has the potential to function better with a more unified research focus. In recent years, the unit has experienced difficulties in attracting good, outside students. Many of them seem to choose instead the University of Helsinki. The courses offered to graduate students are high-quality in spite of the difficulty in offering these over rather different fields. This is one reason why members of the unit have long been very active in the annual Jyväskylä Summer School, which offers specialised courses in a wide range of topics with the best teachers obtainable. Many of them come from abroad and the school also accepts foreign students. The establishment and location of the school at the UJ have great importance for both the Department of Physics and this particular unit, and this importance will be sustained with sufficient, secured funding for the future.

Research networking and interaction

In spite of its relative smallness, the unit has a large network of collaborators and contacts. It is actively involved in most large-scale high-energy physics experiments in Finland running at CERN and simultaneously participates in several planning committees for future collaborations. This involvement is especially strong in connection with the programme in ultra-relativistic heavy-ion physics. The unit has a long tradition of outreach activities. Especially noteworthy is the number of popular books written by members of the unit presenting fundamental physics and new results about the physical world from the smallest elementary particle to the largest in the universe. This activity has the potential to become even more visible and important in connection with planned neutrino experiments in Pyhäsalmi mine, which should generate much public interest.

Research infrastructure

Most of the experimental facilities are operated together with HIP and are found at CERN. The unit itself is located on the rather modern and practical premises of the UJ campus. On-site infrastructure is to a large extent shared with the nuclear physics division. Much of the funding for local infrastructure comes through the university and is found to be adequate at the present time.

Recommendations

The unit seems to lack a clear vision for the future as well as long-term strategic planning. With a stronger research focus and increased ambitions, the unit could function better in the coming years. The unit should work towards a clearer research profile, which also should help it attract more good students. High-energy heavy-ion research would benefit from being incorporated in the much larger nuclear physics group where this is a traditional field. As compensation, the remaining unit should get extra support to strengthen its activities within unified theories, neutrino physics and cosmology. It would then have the potential to play a key role in high-energy physics, should the new neutrino detectors be approved for the Pyhäsalmi mine.

4.21 University of Oulu, Electron Spectroscopy

Overview

The Electron Spectroscopy research group is at present the largest group within the Department of Physics at the University of Oulu (UO). It has two professors, one Academy Professor, six researchers, nine graduate students and a computer technician. External funding for the unit amounts to some EUR 1 million, which is obtained from the Academy of Finland, Tekes, industry and the EU.

Research profile

The unit's research is focused on studies of the electronic structure of solids, clusters, molecules and atoms by electron spectroscopy techniques. A significant part of the research is done at synchrotron radiation facilities around the world. In parallel with the experimental activities, the unit has developed a theoretical program to analyse the experimental results. The combination of experimental and computational programs in the same unit gives unique possibilities with which to understand complicated molecular processes.

Research quality

The research quality is very good and the unit publishes 20–30 papers annually in good physics journals. Members of the unit are often invited to give talks at international and national meetings. Another indication of the high quality is that the unit regularly gets beam time at the most oversubscribed beam lines at international synchrotron radiation facilities. The unit also produces a relatively large number of good PhD students.

Research environment

The condensed matter groups at the UO, the Electron Spectroscopy group being one of them, have not in the past engaged in efficient and open scientific collaboration, and even in the teaching the curricula for the various specialties (NMR, electron spectroscopy, theoretical physics and biophysics) have been largely separated. This situation is now changing so as to create a more collaborative atmosphere.

The unit lacks administrative support. There are no secretaries in the Department. The UO has centralised all secretarial support, making the turnaround time for a secretarial task uncertain. As a result, the principal investigators have to do most of the administration of research grants themselves. This decreases the amount of effort they can direct to research.

Research networking and interaction

The unit has a very large international network and collaborates with scientists from all over the world. This has led to several joint publications with foreign scientists. In particular, the unit has regular and fruitful exchange with researchers in the Nordic and Baltic countries, but also with groups in France, Germany and many other countries. The unit also coordinates SR-MAXIV, a multidisciplinary consortium preparing for the new MAX-IV and involving four Finnish universities.

Members of the unit, both senior scientists and PhD students, often spend time in research groups abroad, mostly in France and Sweden. This ensures that PhD students are exposed to an international research atmosphere during their studies. The unit has also set up a double degree PhD with KTH Royal Institute of Technology in Sweden and established an industrial network. Even though details around the network are secret this should be applauded, since applying and explaining advanced electron spectroscopy techniques to the steel industry is a hard but necessary task in order to increase the competiveness of the Finnish industry.

Research infrastructure

The unit has built up an excellent research infrastructure in-house and a network to use synchrotron radiation sources. Through the Finnish collaboration with MAX-LAB, the unit has access to several beam lines with different experimental conditions. Recently, the unit has been one of the driving forces behind the FINEST-Branchline at MAX-III, which is a very high-resolution beam line mainly for gas phase studies. The unit has also set up an in-house laboratory in which advanced experiments at synchrotron radiation sources can be prepared and students can get their initial training. Among the instruments in the laboratory, there are two Scienta electron analysers. An important and impressive instrument is the cluster source, which the unit has developed.

Recommendations

The unit receives international recognition and has successfully built up and established an advanced research programme. As the unit is now going through a leadership change, it is of the highest importance that the new professor receives full support from the university and from other funding agencies.

The UO should help the unit with EU and other international applications. With the large and active international network of the unit, a substantial increase in project funding is most likely. The UO should also increase its administrative support for scientists in general.

The unit is critically dependent on Finland's engagement in international and European synchrotron radiation sources. The unit is also excellently positioned to take full advantage of the international development of free-electron lasers. The evaluation panel recommends that the Ministry of Education, Science and Culture consider investing in memberships of Finnish groups to make use of free-electron laser facilities.

4.22 University of Oulu, Neurobiophysics

Overview

The Biophysics research group at the University of Oulu (UO) is the only unit in Finland that offers graduate degrees in biophysics. It is a small unit, with one professor, one part-time professor, one part-time lecturer, two postdoctoral researchers, seven graduate students and one computer technician. The current direct funding of EUR 420,000 per year is adequate and comes from the Academy of Finland, national doctoral training programmes and private sources. The annual fee for space is paid by the Department of Physics and there is equipment money.

Research profile

The neurobiophysics research group studies neural information, its generation, transmission and computation by sensory cells and neurons. The unit uses electrophysiology techniques to investigate the visual system of insects, especially under extremely low light conditions. The neural system of insects consists of about one million neural elements, far fewer than in humans, who have approximately 1011 neurons, but complex enough to produce interesting and adaptable behaviour. The unit supports its experiments with in-house computer modelling. In addition, the unit develops novel experimental techniques, for example, electrophysiology tools and a dynamic virtual reality system for stimulating the visual system of cockroaches.

Research quality

The research quality is quite good. The innovative development of a virtual world has garnered quite a lot of attention in the media, and is being used at Lund in Sweden and at the Max Planck Institute at Frankfurt in Germany.

Research environment

Although the unit's research funding is adequate at the time of this report, additional funding needs to be secured. The unit is active in two national doctoral programmes, the Finnish Graduate School of Neuroscience (FGSN) and iBioMep, and typically graduates 0–1 PhDs per year. The typical time to complete a PhD is about 6–7 years. The teaching load on the graduate students is relatively light, occupying about 5 per cent of their work time or 80 hours per year. PhD graduates go on to research positions in industry and postdoctoral positions abroad.

The unit lacks administrative support. There are no secretaries in the Department of Physics. The UO has centralised all secretarial support, making the turnaround time for a secretarial task uncertain. As a result, the principal investigators have to do most of the administration of research grants themselves. This decreases the amount of effort they can direct to research. The administrative load is particularly onerous for the leader of the unit, since he is also the Chair of the Department. He spends about 30–50 per cent of his time on administration and 10 per cent of his time on teaching.

Research networking and interaction

The unit collaborates with other researchers at the UO and works with colleagues at other Finnish institutions through national doctoral training programmes. There is not much research collaboration on a national scale because of the unique nature of the unit's research. No other research groups in Finland are doing what this unit does; there is not much overlap with the efforts of other neuroscientists in the country. However, there is significant international collaboration with researchers from Canada, Germany and the UK. Students travel abroad to visit foreign collaborators and attend international conferences. Except for a small spin-off company (Sensapex) that was started by one of the senior researchers, there is no collaboration with industry.

Research infrastructure

The unit has built its entire infrastructure itself. The laboratory space is adequate though somewhat small and cramped. For its computer modelling, the unit uses the national supercomputing facility of CSC. Gene sequencing is done at a national sequencing facility, though this is somewhat expensive and the turnaround time tends to be slow.

Recommendations

The unit would greatly benefit from more secure long-term funding. The current funding is short-term (3–4-year duration). The unit would also benefit from larger laboratory space. In general, serious consideration should be given to having more biophysics research in Finland. Training PhDs in biophysics would provide the technical expertise to foster greater economic diversity with the establishment of biotechnological and pharmaceutical companies.

4.23 University of Oulu, NMR Spectroscopy

Overview

The NMR (Nuclear Magnetic Resonance) research group at the University of Oulu (UO) has a long and successful history in the field of NMR. It is presently the only physics-based NMR unit in Finland. At present, the unit consists of one professor, one professor emeritus, one university lecturer, one senior researcher, one

Academy Research Fellow, four postdoctoral researchers and one laboratory engineer. In 2011, the unit's total funding amounted to EUR 846,000, of which EUR 437,000 was core funding. External project funding from the Academy of Finland and national doctoral programmes amounted to EUR 227,000.

Research profile

The unit consists of two branches: an experimental and a theoretical/ computational branch. The experimental research is divided into three topics: liquid crystal NMR, noble gas NMR and NMR studies of porous materials, including microfluidistics. One focus of the theoretical branch concerns relativistic effects on NMR parameters, which is important for heavy-atom-containing systems, such as Xe molecules and xenon-guest/host systems of interest for the experimental research. In general, the research has a fundamental character, which is also shown by the fact that the unit has no Tekes funding, although some industry contacts are emerging.

Research quality

The research quality is good, as shown by a large number of publications in good scientific journals. Members of the unit are also invited to international workshops and conferences to present their results and ideas.

Research environment

The condensed matter groups at the UO, the NMR research group being one of them, have not in the past engaged in efficient and open scientific collaboration, and even in the teaching the curricula for the various specialties (NMR, electron spectroscopy, theoretical physics and biophysics) have been largely separated. This situation is now changing so as to create a more collaborative atmosphere.

The unit lacks administrative support. There are no secretaries in the Department of Physics. The UO has centralised all secretarial support, making the turnaround time for a secretarial task uncertain. As a result, the principal investigators have to do most of the administration of research grants themselves. This decreases the amount of effort they can direct to research.

The UO has experienced some problems in recruiting Finnish students. This is, however, a problem shared by many other good universities. Therefore, an international Master's degree programme, MRM, has been introduced as an additional channel for the recruitment of MSc and later PhD students.

Research networking and interaction

The experimental NMR research group has over the years established a large network in the field of NMR and is well aware of the development of the field. Long-term collaborations include groups at Stockholm University, the University of California, Berkeley, Princeton University, the Czech Academy of Sciences, the Technical University of Berlin, the International Tomography Center in Novosibirsk, Osaka Sangyo University and, previously, the University of Basel. The number of outside co-authors on publications has, however, been decreasing in recent years. There is also collaboration with colleagues at other Finnish universities.

Research infrastructure

The unit has recently received substantial funding (EUR 1.5 million) from the EU and the UO to upgrade the laboratory. Therefore, the laboratory now comprises 600, 500, 400, 300 and 200 MHz instruments, new or renovated. Each instrument is equipped with an appropriate sample environment and measurement system. A separate sample preparation laboratory is also available. For the computational studies, the unit uses the national supercomputing facility of CSC and local Linux clusters.

Recommendations

There is a need to stabilise the experimental programme after the retirement of Professor Jokisaari. Therefore, a new senior position should be established and funded by the UO. Considering the large research infrastructure investments that have been done by the EU and the UO, an adequate staff situation should be established. NMR is one of the most useful experimental techniques that can be applied to several questions related to the forest industry in northern Finland. The UO should also improve their administrative support to the scientists.

4.24 University of Oulu, Space Physics

Overview

The Space Physics group of the University of Oulu (UO) Department of Physics consists of two topical subgroups – the Space Climate Group and the Ionospheric Research Group, both headed by a permanent university professor. The groups further consist of two senior researchers and on average two doctoral students as well as one more academic staff member at Master's level assisted by one or two research assistants, depending on third-party funding.

Research profile

The research profile of the unit contains two directions: research on space climate and research on the ionosphere, including magnetosphere-ionosphere coupling, radar analysis and signal processing. The space climate group is internationally recognised as one of the initiators of this newly emerging space research field aiming at the study of long-term (decadal and longer) changes in the heliosphere and in the Earth's charged and neutral environment due to changes in solar activity. Space climate research exploits several international satellite and ground-based databases that cover the last 30–170 years.

The ionospheric research direction aims at the efficient use of the international incoherent scatter radar facility EISCAT (European Incoherent Scatter Scientific Association), which has transmitters in Tromsœ and on Svalbard and additional receivers in Kiruna and at Sodankylä Geophysical Observatory. The radar results are combined with other ground-based and in situ space measurements, for example, of the multi-spacecraft mission CLUSTER of the European Space Agency ESA.

Research quality

The quality of research is high in both research directions of the unit. This has led to a strong involvement of both subgroups in international collaboration, invitations to international conferences and collaborative work as well as peer-reviewed publications (16 in 2011 by the four senior research members of the unit). Doctoral students usually publish six scientific papers before they defend their theses.

Research environment

Especially the nearby Sodankylä Geophysical Observatory provides an excellent research environment for the unit. The teaching and research tasks are distributed among all unit members.

Research networking and interaction

Both subgroups of the unit are very good at networking, especially the Space Climate

Group, which has won a number of EU-funded grants in close collaboration with other groups in the field (SOTERIA project, eHEROS, ESPAS and COST ES1005). For example, in one of these cooperative projects, the Oulu space physicists developed a data server that calculates and disseminates geomagnetic storm indices, which are now broadly used in the international community. Members and former members of the group are very active in national and international professional committees.

Research infrastructure

The unit uses a large number of national and international infrastructures outside Oulu, especially the EISCAT facility at Sodankylä. In addition, it maintains several data servers that can be accessed nationally and internationally.

Recommendations

Most of the work of the Space Physics group is closely related to observations carried out at Sodankylä Geophysical Observatory. In view of the consolidation of the research in both units, the evaluation panel encourages attempts to interact more closely and efficiently in the future, for example by finding a common umbrella like the Kumpula Space Centre in Helsinki. This should include common university teaching and a coordination of the R&D carried out both in Oulu and at Sodankylä. This is especially important in view of the planned reform of the PhD programme funding, which will distribute funding for PhD students not directly to the units but via the universities. Here, and in other respects, a strategically oriented umbrella for collaboration of the space-research-related Sodankylä Geophysical Observatory and the University of Oulu Space Centre would provide a stronger position in accordance to its common value.

4.25 University of Oulu, Sodankylä Geophysical Observatory

Overview

The Sodankylä Geophysical Observatory was founded in 1913. It is uniquely located at high latitudes. In 1997, it became an independent institute of the University of Oulu (UO). The unit comprises a highly versatile observatory that is well equipped technically. During the evaluation period, it has had, on average, 36 staff members, 21 of whom hold an academic degree. As of 2012, a university professor has been appointed in the framework of a joint professorship of the UO and the unit.

Research profile

The research of the unit is dominated by observations of the high-latitude ionosphere using practically the whole spectrum of magnetic and electromagnetic information that is actually available.

Research quality

The unit, together with other Finnish scientists, has become a world leader in the field of solving the inverse problem of interpreting radar data. The observational programs and instrumental equipment are of highest international standards; EISCAT (European Incoherent Scatter Scientific Association), for instance, is the only tristatic radar in the world. The unit extensively publishes its results in refereed scientific journals (some 30 articles per year plus some 45 in non-refereed journals and proceedings).

Research environment

The research environment of the unit is unique due to its location at high latitudes, its up-to-date equipment, the scientific research carried out as well as the highly qualified technical staff. This makes it an excellent place for researchers from all over the world who each year stay for many months at the observatory.

Research networking and interaction

The unit is well established as a partner of multiple international and Finnish national research networks. It provides observatory platforms as well as a number of guest instruments via which it interacts with ionospheric research groups all over the world. Nationally, the work of the ionospheric and magnetospheric research groups at the unit is closely related to that of the Space Physics group of the UO Department of Physics.

In 2006–2011 and again in 2012–2017, the unit was and is part of the Finnish Centre of Excellence in Inverse Problems, in which field Finnish scientists have become world leaders.

Research infrastructure

The unit provides high-quality observatory platforms for magnetometers, riometers, pulsation magnetometers and ionospheric tomography receivers widely used by the international ionospheric research community. It hosts an ionosonde, a meteor radar, an EISCAT radar site, all-sky auroral cameras and VLF (Very Low Frequency) receivers as well as a number of guest instruments. The planned extension of the EISCAT radar system to EISCAT-3D would make the unit an even more important place for ionospheric physics worldwide.

Recommendations

The work of the ionospheric and magnetospheric research groups at the unit is closely related to that of the Space Physics group of the UO Department of Physics. The two units should be supported in their attempt to interact more closely and efficiently, for example by finding a common umbrella like the Kumpula Space Centre in Helsinki, including common university teaching and a coordination of the research and development carried out both in Oulu and at Sodankylä. This is especially important in the view of the planned reform of the PhD programme funding, which will distribute funding not directly to the units but via the universities. A combined Sodankylä-UO Space Centre would have a much stronger position matching its value to the community.

4.26 University of Oulu, Theoretical Physics

Overview

Theoretical Physics is the smallest unit within the Department of Physics at the University of Oulu (UO), with only one professor at the present time. In addition, there is one senior researcher who is close to retirement. They both work in condensed matter physics and have 2–3 graduate students. Most of the unit's budget is core funding, with external funding coming from the Academy of Finland and private foundations. In addition, there is direct support from the Ministry of Education, Science and Culture for one graduate student.

Research profile

The main activity in the unit is defined by the professor and his long interest in Fermi liquid theory with special emphasis on superfluid helium-3. This is done in collaboration with former colleagues in several groups at the low-temperature laboratory at Aalto University (AU). Another area of research is Josephson junction qubits, which are one of the leading candidates for making a quantum computer. A smaller activity by the senior researcher concentrates on many-body problems and Bose-Einstein condensates. He has been member of an EU COST programme, but the research visibility and output is not so high.

Research quality

The work on Fermi liquids and superfluidity has long been of high quality and original. Many of the PhDs coming from the unit have found postdoctoral positions abroad. This is a good indicator of their quality. The unit has the potential to continue in this positive direction and the Department should encourage this activity to flourish. With the hiring of a new professor in a related field, this small unit could become much more visible within the condensed matter physics community.

Research environment

In spite of its smallness, the unit teaches an inordinately large number of physics courses. The professor views this as a privilege, which is a refreshing point of view. There is a lack of ambition in the unit, which is also reflected in the rather low number of students it attracts. Most of them come from the local area. Since their number is small, they receive correspondingly more time and attention from their supervisors. In spite of these positive aspects, the unit should make more efforts to attract additional students. This should be facilitated with the appointment of a new and tenured faculty member with the right qualities who could increase the visibility of the unit.

Research networking and interaction

The main collaborators of the unit are at the low-temperature laboratory at AU. In addition, the unit has normal, professional contacts with colleagues abroad. At the present time, the unit does not take part in any networks except for the European COST programme. It has no systematic outreach programme, which also partly explains its lack of visibility and low number of students. The unit would benefit from ameliorating this situation.

Research infrastructure

Doing research in theoretical physics, the infrastructure of the unit is provided by the Department. It has access to sufficient computer power and has at the present time no plans to start more computationally demanding projects. It is housed centrally in the Department of Physics, with easy access to other divisions. It can easily accommodate more students.

Recommendations

The unit needs to strengthen its activity in theoretical condensed matter physics. A faculty position will soon be made available, and the evaluation panel recommends that the Department use this opportunity to hire a condensed matter theorist. In closer engagement with the Department, the unit should raise its ambitions and come up with a well-stated vision for its future activities and goals.

4.27 University of Turku, Materials Research Laboratory, Laboratory of Industrial Physics, Wihuri Physical Laboratory

Overview

The Materials Research Laboratory, the Laboratory of Industrial Physics and Wihuri Physical Laboratory of the University of Turku (UT) Department of Physics and Astronomy form a large and relatively heterogeneous unit of three subgroups with efforts in: (i) detectors/synchrotron physics; (ii) industrial physics; and (iii) low-temperature physics. Materials physics is covered transversally as all the subgroups effectively contribute to the characterisation of a large variety of materials. The unit includes four full professors and one senior researcher as head of the industrial physics lab, two lecturers, 4–6 postdoctoral researchers and some 15 graduate students. Of the unit's funding, approximately 30 per cent comes from core sources, nearly covering only personnel costs. Some 30 per cent of the funding is accounted for by private sources such as the Wihuri foundation, with the rest being mostly attributable to the Academy of Finland.

Research profile

The subgroup working on synchrotron radiation spectroscopy and detectors is active in both instrument development, theoretical modelling and analytical techniques available at such large facilities for characterisation of the properties of materials of interest. It works on molecular systems, clusters, and semiconductive and magnetic materials that are also at the core of the interests of the magnetism and superconductivity subgroup.

The industrial physics subgroup is very active in the characterisation of materials of industrial relevance. Particularly important among these are materials for the pharmaceutical industry, such as nano-porous silicon for drug delivery, but also polymers and plastics. Such activity on pharmaceuticals attracts significant funding from the private sector and the EU, but is not sufficiently prioritised by the UT, for example, with funding for a professorial position for the group. Work in the low-temperature physics area covers a very diverse ground spanning from magnetism and superconductivity to metallic nano-contacts physics and atomic hydrogen.

Research quality

The research quality of the unit is medium to high. The scientific output is sustained in terms of papers and active collaborations across the spectrum of the research teams and levels. Publications are in well-established refereed journals with an international profile. There are, however, significant margins to increase both the impact and the international visibility of the publications.

The synchrotron radiation spectroscopy subgroup is well connected and able to interact with major large-scale facilities and make a significant and original contribution to development on original instruments for materials characterisation. There is a good level of originality also in the area of thermal characterisation of industrial materials, spin-valves and theoretical understanding of HTSCs (High Temperature Superconducting Materials) and atomic hydrogen. Overall, considering the number of permanent academics and non-permanent staffs and students, and especially the level of funding, the unit potential does not seem to be fully exploited yet.

Research environment

The Wihuri foundation provides some precious and pretty unique funding that powerfully contributes to the core funding from the university and that crucially allows the unit to pursue some fundamental work (e.g. on atomic hydrogen) requiring a relatively high expenditure on consumables. The unit is trying to increase its visibility with the top management of the university, although there does not seem to be a structured strategy. While there is some coordination among academics within the unit, this appears relatively loose, and there does not seem to be a well-defined vision for the growth of the unit and for the stabilisation and career progression of all staff; for example, there is no full (tenured) professor in the industrial physics subgroup, despite the significant level of funding attracted.

Education is one of the top priorities of the Department, which attracts some 450 applications every year, of which only some 55 each are accepted (with approx. 45 turn-ups per year), thus allowing the Department to select the very best students on a national scale. The obsolete equipment is still functional for teaching and education, but the unit needs to develop an agenda of high-level interactions within the UT to leverage its success in attracting the best students in Finland.

The unit has a well-structured approach to PhD training at unit level. The relatively large group size allows the unit to distribute the administrative and teaching load in a well-manageable manner, although more help from administration would be particularly welcome for EU grants, both at the application stage and in managing the significant administration load needed to operate the grants.

Research networking and interaction

In addition to good internal collaboration and sharing of the equipment basis, the synchrotron radiation spectroscopy subgroup has a very strong network of collaboration, namely with Sweden, Estonia, France and the US. The other subgroups have a number of interactions that also include Åbo Akademi university, among others (incl. MIT), which recently led to some notable results on spin-valve, for example. This is also a multidisciplinary collaboration.

The magnetism and superconductivity subgroup has several interactions, also in relation to the use of its pulsed high-magnetic field facility, which, however, still has a lot of potential to achieve effective usage. Similarly, the atomic hydrogen subgroup still has significant margins to improve its network of interactions, thus also contributing to raising its international profile. An obvious strategy would seem to be to seek complementarities and synergy with the low-temperature physics activities at Aalto University, and to try to leverage the inertia of that group and the opportunities for both scientific discovery and networking that this would provide. This would also open up significant additional opportunities of other members of the subgroup (e.g. metallic nano-contacts, and materials in general) for specialised characterisation techniques, and the chance to discover new physics in their systems of interest.

Industrial collaboration is channelled mainly through the industrial physics subgroup. While this is very good, and attracts significant funding, there is a risk that the other subgroups are somehow less encouraged to pursue technology transfer and interaction with industry. A vision for a structured approach to IPR protection and exploitation, up to spin-off formation, and to attraction of industrial funding, should be developed at unit level. The unit should also consider formalising a requirement to provide PhD students with a minimum training or secondment period at other universities, to extend the range of competences within the spectrum useful to the single projects.

Research infrastructure

The unit is partly well funded, but there are several items, especially surface characterisation equipment, that are obsolete and that, although still alright for teaching purposes, would need to be replaced for the purpose of research. The unit maintains and operates a good number of local X-ray machines that are somehow outdated but functional for the purposes of the unit. The thermal characterisation equipment is mostly recent and essentially state-of-the-art, also thanks to additions and further developments by the unit itself. The equipment for high pulsed magnetic field does not appear to be intensely used, especially by internal users. The relatively old age (20 years and more) of many apparatuses (XPS/AES, or X-ray photoelectron and Auger electron spectroscopy, and other surface characterisation machines) limits the ability of the unit to develop its full potential on themes of current outstanding impact and therefore limits the future ability of the unit to maintain a good level of publication and funding.

Recommendations

The unit needs to develop a strategy for replacement of obsolete equipment, in agreement with the Department, the Faculty and the UT at large, and possibly with the Academy of Finland, given the substantial funding required that is not compatible with the level of Wihuri funding. It is important however, that this strategy be developed in tandem with a vision for the research mission of the Department as a whole, so as to assess the urgency of the need for this equipment within the context of the most successful research strands in the Department. The successful collaboration with Åbo Akademi University in certain areas could be used as a starting point for strengthening the research base, with a long-term view to realising a federation of the two universities, or even a single, merged university. More support from central administration to deal with the paperwork connected with EU proposal application and managing would perhaps allow the unit to increase its success rate in the competition for EU funding.

4.28 University of Turku, Laboratory of Optics and Spectroscopy, Laboratory of Theoretical Physics

Overview

The Laboratory of Optics and Spectroscopy and the Laboratory of Theoretical Physics at the University of Turku (UT) are two comparatively small laboratories working largely independently. The former consists of one experimental and one theory group, while latter has four subgroups: computational materials science; particle physics and cosmology; nonlinear physics; and operational quantum mechanics. Overall, the combined unit has three professors, six senior researchers and one postdoctoral researcher. The average number of full-time doctoral students in the evaluation period was 15. Over 60 per cent of the unit's budget comes from core funding. About two-thirds of the external funding is provided by the Academy of Finland. The rest of the external funding stems from several different sources including Tekes and EU programmes.

Research profile

Given the size of the unit, the research spectrum is extremely broad. It includes experimental activities in optics and spectroscopy, in particular spectroscopic gas detection, and theoretical activities in the areas of quantum optics, particle physics and cosmology, computational materials science, nonlinear physics and operational quantum mechanics. Each of these activities is carried by a professor or a single permanent researcher, with very limited personal resources and apparently rather independently. In 2009, four of the unit's groups and an experimental group of the Wihuri Physical Laboratory started the Turku Centre for Quantum Physics in order to shape the research profile in the future. However, within the period of evaluation, this new virtual structure seems to have had little impact on the research profile of the unit.

Research quality

As a whole, the research quality of the unit as judged by the research output is moderate to good. The rate of publication is good and most of the articles appear in good and relevant journals. However, there are clear differences between the groups of the unit. Whereas some activities appear to be cutting-edge research and internationally visible, such as the quantum optics research, some activities are rather moderate or even below standard. This is also reflected by differences in the ability to attract external funding for the different groups. One main reason is the very broad and diverse spectrum of research topics, which for most groups within the unit results in a subcritical size. The level of EU funding is rather low and there is also no high-profile national funding like Centres of Excellence, for example. There has been no industrial funding for the last two years of the evaluation period.

Research environment

The research environment appears to be poor. The administrative support of the university is apparently very limited, which impacts especially the ability to apply for certain types of external funding and handle those grants. For example, for EU funding nowadays, it is really crucial to have experienced administrative support. If this is put on the shoulders of the researchers, it not only results in a reduction in time left for research, but it also produces a lack of professionalism. Furthermore, there is clearly insufficient support on the secretary level.

The unit is responsible for organising theoretical lectures. The teaching load on the professors and senior researchers is comparatively high, which also has some negative impact on the time budget for research. There is some collaboration with other departments, especially with the Department of Mathematics and Statistics. The UT does not provide any significant start-up funding for new appointments. This makes it almost impossible to appoint a good experimentalist. Although the unit is undergoing a vast change, because of several coming retirements, it seems that no clear plan for filling these positions is in place. This is in part again due to the lack of commitment at the university level, which makes it hard to put in place any realistic plan supported by the unit, the Department and the UT.

Research networking and interaction

The research networking and interaction is also very different for the groups in the unit. Generally, however, it is clear that collaborations on a national level are largely missing. This is clear from the limited number of national co-authors on papers. Internationally, there is some individual collaboration, which is reflected by the fact that half of the publications are co-authored by a foreign researcher. However, there is a clear lack of high-profile foreign visitors to the unit, indicating that the networking activities of the unit are generally rather poor.

Research infrastructure

There is some infrastructure for computational physics, but it would be vital for a large part of the unit that a local node of access to the CSC be established. Most of the activities are theoretical projects and the only experimental activity will be terminated by the retirement of the head of the unit later this year. Therefore, there is no experimental infrastructure associated with the unit.

Recommendations

The evaluation panel recommends that the unit, together with the Department of Physics and Astronomy and the UT, draft a detailed structural plan for the near and mid-term future. Clearly, a stronger focusing of the research profile is needed, and the upcoming reappointments should be used to achieve this. The panel believes that the establishment of the Turku Centre of Quantum Physics can be a step in the right direction, if the UT and the Academy of Finland are willing to support it substantially. This support should be based on a strategic plan of this Centre and clear improvements of the research environment. It seems doubtful that the present members of the unit can shape this transition without external help. Therefore, the panel strongly recommends that the UT consider appointing an external board or external temporary director for the Centre, who can guide this transition. Furthermore, it seems absolutely evident that the experimental activities of the unit should be strengthened, especially since the future of the only experimental group is uncertain because of the retirement of its head. This should be part of a balanced plan for the Centre. For such an experimental group, start-up funds should be provided to be able to make a meaningful appointment.

The UT should also consider establishing professional administrative help for funding applications and handling of grants, in addition to providing help at the secretary level for the unit. Furthermore, the local node for access to the CSC should be realised.

4.29 University of Turku, Space Research Laboratory

Overview

The small Space Research Laboratory at the University of Turku (UT) consists of one professor (still on a non-permanent position), one laboratory engineer and one project scientist, all funded by the university but with non-permanent positions. In addition, there are a few doctoral students on project funding obtained from the Academy of Finland and the EU. The unit's work is strongly dependent on soft-money funding for space instrumentation, mainly from Tekes. The unit works largely independently from the other branches of the UT Department of Physics and Astronomy. During the evaluation period, about two-thirds of the unit's total funding of EUR 2 million has been core funding, while Tekes and the Academy of Finland have provided close to one-third.

Research profile

The unit has long been involved in the instrument building and the subsequent analysis of obtained data on high-energy particle and cosmic-ray observations in space. The main data source for the unit's work is its own PI instrument ERNE onboard the SoHO spacecraft, the European Space Agency's (ESA) Solar Heliospheric Observatory, which was launched in 1995 in collaboration with the US. This mission has already been extended until 2013, and it might be further extended until 2016. Before the launch of the next Solar Space mission, the spacecraft "Solar Orbiter", which is planned for 2017, the unit will continue to utilise the SoHO-ERNE data as well as the energetic particle data of the IAMS instrument, launched in 2011 to the International Space Station, to which the unit also contributed. While preparing the LET (Low Energy Telescope) instrument for launch with the Solar Orbiter in 2017, the unit analyses energetic particle data and develops computer models appropriate to analyse these data.

Research quality

The unit is internationally recognised mainly for its successful instrument development. The research quality is good, though the research is limited by the small and fluctuating number of active researchers (the only postdoctoral researcher just left for the UK) and by partially outdated equipment.

Research environment

The group interacts mainly with the international space community, partially also with the Finnish space research groups and within the UT with the Department of Physics and Astronomy by lecturing to Bachelor's and Master's students. In spite of its small size, the unit is heavily involved in teaching, especially at the Bachelor's level and on special themes in a broad range of topical lectures. This teaching is mainly done by the unit's professor, while the technician and the scientist have one course each. In terms of research, the unit seems to be rather isolated at the UT.

Research infrastructure

The unit's work on space research instrumentation has been recognised in the strategy of the UT for the years 2013–2016, which states that the astronomy and the space physics infrastructures are among the profiling infrastructures of the university's research. Unfortunately, in spite of this recognition in the strategic planning, the unit needs stronger support, for example for computers and equipment, which hopefully will become available soon, when the space project under preparation (LET onboard the Solar Orbiter) will be funded by Tekes. For scientific computing, the unit mainly uses the resources available at the CSC, while the local computing resources are weak, that is, the use of actual IDL software is not funded.

Research networking and interaction

The unit is involved in national collaboration with the University of Helsinki and the University of Oulu. It also cooperates with space research groups in Germany, Greece, France, Italy, Spain, Switzerland, the UK, Ukraine and the US.

Recommendations

For the survival of the energetic particle group at the UT, what is needed is first of all a positive decision on the funding of the Finnish LET instrument contribution to the Solar Orbiter. Further, for the unit to be continued, it should be rejuvenated as soon as possible to work also on theory and interpretation of energetic particle data in parallel with the LET instrument in order to be able to carry on the research beyond the launch of the Solar Orbiter in 2017. This should be taken into account when filling the professorship in 2012. Alternatively, the energetic particle space research could be moved to one of the other Finnish space research centres, for example to Kumpula in Helsinki or to the University of Oulu in Sodankylä. Also, the infrastructure calls of the Academy of Finland should be addressed actively. The unit should also seek funding for inviting visitors and guests as well as for attending international conferences to present the results of the unit's work.

4.30 Åbo Akademi University, Physics

Overview

The main subject of Physics at Åbo Akademi University (ÅA) is led by one experimental and one theoretical professor. In addition, there are two lecturers, one laboratory engineer and several postdoctoral researchers working in the unit. Previously, the educational activity involved also two teaching assistants, but that part has been discontinued. The number of graduate students has been around 10 during the evaluation period, but the corresponding number of awarded degrees is lower than expected. In the administration, the unit has been helped by a secretary, shared with the rest of the department. The teaching staff have stable funding from ÅA while the research staff are supported by external funding. This funding is about equal in size compared to core funding.

In addition to educating and maintaining Swedish-speaking scientists and experts in physics on internationally competitive levels, the unit also has responsibility for a complete MSc programme in physics for the education of teachers. In addition, there is a permanent need to offer courses in physics for students taking physics as a minor subject in other fields of natural sciences and engineering. In materials science and nuclear physics, the unit offers graduate programmes.

Research profile

The dominant research interest of the unit is within condensed matter physics with an emphasis on materials science. Both professors work within this field, where the biggest activity is in connection with organic electronics and printed functionality. This group within the unit is part of a much larger Centre of Excellence in functional materials shared with the main subject of Chemistry. The theoretical work in this field is concentrated around semiconductor optics.

A much smaller activity is within solid state physics, with an emphasis on the structural analysis of iron-based materials. In addition, there is research in experimental, nuclear physics done at accelerators in other laboratories. The unit has also been central in organising two large international conferences during the evaluation period.

Research quality

Measured in terms of scientific output and visibility, the unit's activity in organic electronics receives high scores. However, the total output from in terms of publications in refereed journals is rather low. In spite of this, the relative citation rate is rather high both at the national and international level. Had it not been for the research in organic electronics within the Centre of Excellence, the output and quality of the research would have been below the expected level. This situation must be improved if the unit wants to continue as an active research unit.

Research environment

Since the unit serves the Swedish-speaking minority in Finland, it has a political mission in addition to its scientific interests. These two goals are not always easy to combine. For this reason, the unit attracts only students with this particular language background and has therefore in recent years experienced a decline in the number of new students. There are no indications that this trend will change. The basic running costs of the unit are stable, but it lacks a long-term, strategic plan for when new positions will open up after retirements. If politically possible, from a scientific point of view, the unit would benefit from a closer affiliation with the Department of Physics and Astronomy of the University of Turku.

Research networking and interaction

The activity in organic electronics as a part of a joint Centre of Excellence has a close collaboration with the main subject of Chemistry and with many groups in other countries. Similar collaborations take place between the activities in solid state and nuclear physics within the unit and other national and Nordic institutions, but on a correspondingly smaller scale. At the more elementary level, the unit offers public lectures for the general public in the Turku area, which are also made available on the web. The unit also arranges school visits to demonstrate the area of physical phenomenology in order to increase familiarity with the science offered by ÅA. This includes supervised laboratory work for student groups from local schools. In addition, the unit co-organises a biannual physics meeting for Swedish-speaking scientists, teachers and students in Finland.

Research infrastructure

In-house infrastructure exists in the form of electro-optical instruments for characterisation of disordered organic materials as well as Mössbauer equipment. In the Centre of Excellence for Functional Materials, there is a custom-built hybrid printer that has attracted a lot of outside attention. For the other two activities in the unit, the experiments are done at other institutions in Finland and abroad. The main problem with the infrastructure is the old Gadolinia building in which the unit is housed. The working conditions have gradually worsened, with water leaks and bad ventilation. This deplorable situation must soon be improved by a general renovation of the building if the unit shall continue to be located there in the future.

Recommendations

The unit is subcritical in both size and activity and has problems in attracting a sufficient number of good students. It is located in a building that needs renovation and upgrading. All this could be ameliorated by integrating it with the Department of Physics and Astronomy of the University of Turku, as is the case for the corresponding Swedish-speaking unit in Helsinki.

Appendix A. Statistics on physics research in Finland 2007–2011

A1. Introduction

This Appendix is based on data from the evaluation forms sent to the units (Appendix D). The form consisted of two parts. Part I requested basic quantitative data from the evaluation period: personnel resources, funding, research output, education and collaboration. Part II was for the self-assessment: the units were asked to describe their research profile and strategy, provide a SWOT analysis, give a detailed description of infrastructure, collaboration and publication activity, and outline future prospects. Only Part I data is used in this Appendix; the Part II data were intended for evaluation purposes only. This report summarises, using tables and graphics, selected quantitative data from Part I.

Two remarks should be kept in mind when this Appendix is used to assess the resources and results of Finnish physics research as a whole and, on the other hand, of the individual units of the evaluation. The units covered by this report where chosen according two main criteria: they should belong to physics departments or have otherwise clearly physics-oriented research profiles; and they should not have been included in recent evaluations of the Academy of Finland (or planned to become included in some other near future evaluation). Especially the following areas are, in their main parts, not covered by this evaluation:

- theoretical and computational physics research done in mathematics departments
- physics research within energy research (Academy evaluation 14/06)
- Physics research within engineering sciences (Academy evaluation 5/08)
- Geophysical fluid dynamics and other geophysics (Academy evaluation 14/03), meteorology and parts of atmospheric physics
- Areas of materials science and research fields combining physics and chemistry (Academy evaluation 1/11).

Thus, there are physics fields that are quite completely covered in this report, such as high-energy physics, and others that are covered only in part, such as fluid and plasma physics. Practically in all other fields than high-energy physics, there are groups that are not included in the evaluation but are conducting research very similar to that of some evaluated unit. This is especially so in research related to materials science and applied physics in general. Thus, the total volume of physics research is in reality somewhat larger than shown by the figures in the Appendix.

The other remark is on the comparability of the units. The departments and groups had some freedom to choose how they are divided or combined into evaluation units. In some cases, the whole physics department was evaluated as one unit, in other cases the unit was a division or laboratory within a department, or an individual group. Some units were practical assemblies of research groups rather than coherent divisions, and the included small units could have very different profiles and productivities. The different styles of university organisation are evident here as well. Thus, the impression that about half of the units are quite large while the remaining are much smaller is in part misleading. There are also two special collaborative units not hosted by any single university, Helsinki Institute of Physics and the Kumpula Space Centre.

A2. The units and their host organisations

The units

The evaluated units are listed in Table 1. Several of the universities have undergone restructurings during the evaluation period. The names of the units and their references to the university organisation have therefore changed somewhat. The names refer to the present situation.

Aalto University (AU)

AU was established in 2010, when Helsinki University of Technology (TKK), Helsinki School of Economics and the University of Art and Design Helsinki were merged. AU has 20,000 students, of which the share of the former TKK is about 15,000, and a staff of 4,500. Before 2011, AU consisted of the School of Science and Technology, the School of Economics and the School of Art and Design. As of 2011, AU is organised into six schools: Engineering, Chemical Technology, Science, Electrical Engineering, Business, and Arts, Design and Architecture. Of the evaluated units, the Department of Micro- and Nanosciences belongs to the School of Electrical Engineering. The O.V. Lounasmaa laboratory is a separate institute of the School of Science, while the remaining units belong to the Department of Applied Physics in the School of Science.

Lappeenranta University of Technology (LUT)

LUT was founded in 1969 and has presently 5,700 students and a staff of 930. As of 2007, LUT has three faculties. The Faculty of Technology has six departments, one of which is the Department of Mathematics and Physics. It is divided into the laboratories of Mathematics and Physics.

Tampere University of Technology (TUT)

TUT has almost 11,000 students and a staff of 1,800. It was founded as a branch of TKK in 1965 and gained full university status in 1972. Until the end of 2007, TUT consisted of ten departments and 35 institutes. As of 2008, there are five faculties and 22 departments. The Faculty of Science and Environmental Engineering contains five departments, one of which is the Department of Physics. The Optoelectronics Research Centre (ORC) is a separate research institute in the Faculty.

University of Eastern Finland (UEF)

The UEF has two main campuses, Joensuu and Kuopio, and a smaller one in Savonlinna. The UEF was formed in 2010 by a merger of two previously independent universities, Joensuu and Kuopio. It has some 15,000 students and a staff of 2,800. There are four faculties. The Department of Physics and Mathematics at Joensuu and the Department of Applied Physics at Kuopio are among the seven departments of the Faculty of Science and Forestry.

University of Helsinki (UH) and Kumpula Campus

The UH is the oldest and largest of the Finnish universities, with 35,000 students and a staff of 7,600. Its eleven faculties are hosted by four main campuses: City Centre, Meilahti, Kumpula and Viikki. The Faculty of Science at Kumpula houses six departments, of which the Department of Physics in the Physicum building is one of the larger ones. In Physicum is also the headquarters of Helsinki Institute of Physics (HIP), which is a research institute operated by the UH, AU, the UJ, TUT and LUT. Kumpula Space Centre, on the other hand, is a space research umbrella organisation for the UH Department of Physics, the Finnish Meteorological Institute (FMI) and, since 2012, the AU School of Electrical Engineering. The FMI is a research institute with a staff of 600 and its main facilities are located on the Kumpula Campus.

University of Jyväskylä (UJ)

The UJ is arranged in three campuses in Jyväskylä and has more than 15,000 students and a staff of 2,600. There are six faculties and the School of Business and Economics. The Department of Physics is one of the four departments in the Faculty of Mathematics and Science at the Ylistönrinne Campus.

Table 1. The evaluated units and their acronyms

No.	Acronym	Unit name(s) and explanations
1	AU/Materials	Experimental Materials Physics. This unit consists of the following groups in the Department of Applied Physics: Atomic Scale Physics, Molecular Materials, Nanomaterials, Nanomagnetism and Spintronics, Positron Research, and Surface Science.
2	AU/COMP	Department of Applied Physics, Centre of Excellence in Computational Nanoscience
3	AU/MicroNano	Department of Micro- and Nanosciences
4	AU/Optics	Department of Applied Physics, Optics and Photonics
5	AU/LowTemp	O.V. Lounasmaa Laboratory (a.k.a. low-temperature laboratory)
6	HIP	Helsinki Institute of Physics
7	LUT/Physics	Department of Mathematics and Physics, Laboratory of Physics
8	TUT/Aerosol	Department of Physics, Laboratory for Aerosol Physics
9	TUT/Comp	Department of Physics, Laboratory for Computational Physics
10	TUT/Optics	Department of Physics, Laboratory for Optics
11	TUT/Optoelectr	Optoelectronics Research Centre (ORC)
12	UEF/Applied	Department of Applied Physics
13	UEF/Photonics	Department of Physics and Mathematics, Photonics Research
14	UH/Atmosph	Department of Physics, Division of Atmospheric Sciences
15	UH/Particle	Department of Physics, Division of Elementary Particle Physics
16	UH/Materials	Department of Physics, Division of Materials Physics
17	UH+FMI/Space	UH Department of Physics, Division of Geophysics and Astronomy: Space Physics, and Finnish Meteorological Institute
18	UJ/Materials	Department of Physics, Materials Physics
19	UJ/Nuclear	Department of Physics, Nuclear and Accelerator-Based Physics
20	UJ/Particle	Department of Physics, High-Energy Physics
21	UO/Spectrosc	Department of Physics, Electron Spectroscopy
22	UO/Neurobio	Department of Physics, Neurobiophysics
23	UO/NMR	Department of Physics, NMR Spectroscopy
24	UO/Space	Department of Physics, Space Physics
25	UO/SGO	Department of Physics, Sodankylä Geophysical Observatory
26	UO/Theoretical	Department of Physics, Theoretical Physics
27	UT/Group1	Department of Physics and Astronomy: Materials Research Laboratory, Laboratory of Industrial Physics, and Wihuri Physical Laboratory
28	UT/Group2	Department of Physics and Astronomy: Laboratory of Optics and Spectroscopy, and Laboratory of Theoretical Physics
29	UT/Group3	Department of Physics and Astronomy: Space Research Laboratory
30	ÅA/Physics	Physics

University of Oulu (UO)

The UO was founded in 1958 and is the third largest university in Finland with its 16,000 students and a staff of 3,000. The Faculty of Science is one of six faculties and is divided further into eight departments, among which is the Department of Physics.

University of Turku (UT)

The UT is the second largest university in Finland and has almost 19,000 students and a staff of 3,000. There are seven faculties. The Faculty of Mathematics and Natural Sciences includes among its seven departments the Department of Physics and Astronomy.

Åbo Akademi University (ÅA)

ÅA is a Swedish-language university in Turku and has more than 7,000 students and a staff of 1,300. Before 2010, there were ten faculties; as of 2010 three divisions. The four departments of the Division of Natural Sciences and Technology include the Department of Natural Sciences, and physics is one of the four subjects in the Department.

A3. Profile of physics research

The units were asked to specify the proportions of different physics fields in their research (Table 2). There were six defined fields, following a classification used by the Academy of Finland, and two additional classes: "other research within physical sciences" and "other research not within physical sciences".

However, no definition on the demarcation line between physical and nonphysical sciences was given. In the results below, this line is erected in front of materials science and nanosciences, engineering or chemistry. The allocations reported by the units have been unified accordingly. Some summarising observations:

- Six units specified 100 per cent for one of the main six fields and two units 100 per cent for the "other" class.
- For six units, the largest research field did not exceed 50 per cent of the unit's research.
- Twelve units, or more than one-third, reported that their largest research field was "other physical".
- Eight units, or slightly more than a quarter, reported that their largest field was "condensed matter".
- "Fluid and plasma" was not the largest field for any unit, so the field may appear small. However, much of this field has been covered by previous evaluations on energy research, geophysical research and engineering research.

The profile does not look much different from a research volume perspective. Figure 1 shows the percentages of the fields, weighted by the total funding of each unit. The class "other physical" dominates with 38 per cent, while "condensed matter" gets 19 per cent and the remaining fields 43 per cent. Thus, the Academy classification of physics does not perhaps optimally resolve the profile of physics research in Finland, but the subfields within the "other" class are significant. The different "other" fields can be studied from Table 3. Most of the "other physical" research is within four fields: nanoscience and nanotechnology; materials science and related fields; space physics; and atmospheric sciences.

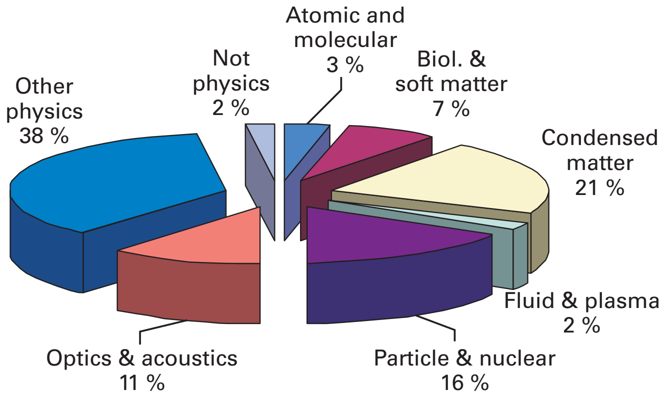

Figure 1. Proportion of different fields of physical research (weighting by total funding of each unit)

Table 2. Research profiles of the units (largest percentage for each unit in bold). The overall percentage is weighted by the total funding of the units.

		Atomic and molecular physics	Biological and soft-matter physics	Condensed matter physics	Fluid and plasma physics	Particle and nuclear physics	Optics, acoustics	Other physics	Other, not physics
	First places	**2**	**2**	**8**	**0**	**5**	**3**	**11**	**0**
	Overall %	**3**	**7**	**21**	**2**	**16**	**11**	**37**	**2**
1	AU/Materials	3	9	**69**	0	0	3	12	4
2	AU/COMP	3	25	**56**	3	0	3	10	0
3	AU/MicroNano	5	5	20	0	0	20	**50**	0
4	AU/Optics	0	0	0	0	0	**100**	0	0
5	AU/LowTemp	0	0	**95**	0	0	0	5	0
6	HIP	0	1	2	0	**79**	0	8	11
7	LUT/Physics	0	0	**45**	0	**45**	0	10	0
8	TUT/Aerosol	0	0	0	0	0	0	**60**	40
9	TUT/Comp	10	**62**	28	0	0	0	0	0
10	TUT/Optics	0	0	0	0	0	**100**	0	0
11	TUT/Optoelectr	0	0	22	0	0	15	**63**	0
12	UEF/Applied	0	40	0	0	0	5	**50**	5
13	EUF/Photonics	0	0	0	0	0	**100**	0	0
14	UH/Atmosph	0	0	0	0	0	0	**100**	0
15	UH/Particle	0	0	0	0	**100**	0	0	0
16	UH/Materials	3	13	8	1	3	0	**72**	0
17	UH+FMI/Space	0	0	0	30	0	0	**70**	0
18	UJ/Materials	8	11	**61**	7	0	3	9	1
19	UJ/Nuclear	0	1	8	1	**90**	0	0	0
20	UJ/Particle	0	0	0	0	**100**	0	0	0
21	UO/Spectrosc	**60**	0	30	0	10	0	0	0
22	UO/Neurobio	20	**50**	0	0	0	0	0	30
23	UO/NMR	**40**	10	30	0	0	0	20	0
24	UO/Space	0	0	0	0	0	0	**75**	25
25	UO/SGO	0	0	0	0	0	0	**100**	0
26	UO/Theoretical	0	0	**75**	0	25	0	0	0
27	UT/Group1	20	0	**65**	0	0	0	15	0
28	UT/Group2	20	0	15	0	5	20	**40**	0
29	UT/Group3	0	0	0	10	0	0	**90**	0
30	ÅA/Physics	0	0	**65**	0	10	0	25	0

Table 3. Main research fields within "other research" for units that reported "other research" as the largest field

	Unit	Other physical 1	%	Other physical 2	%	Other physical 3	%	Other not physical	%
3	AU/ MicroNano	Nanosciences	25	Functional materials	25				
8	TUT/Aerosol	Nanosciences	25	Functional materials	25	Atmospheric sciences	10	Environmental research	40
11	TUT/ Optoelectr	Materials sciences	30	Nanosciences	18	Surface science	15		
12	UEF/Applied	Computational physics	28	Geosciences	22			Biomedical sciences	5
14	UH/Atmosph	Atmospheric sciences	100						
16	UH/Materials	Nanosciences, ion beam physics	31	Medical physics	8	Electronics	7	Surface chemistry	2
17	UH+FMI/ Space	Space physics	70						
24	UO/Space	Space physics	70	Atmospheric science	5			Applied mathematics	25
25	UO/SGO	Space physics	70	Seismology	10			Applied mathematics	20
28	UT/Group2	Mathematical physics	40						
29	UT/Group3	Space physics	60	Communications engineering	20	Computational data analysis	10		

A4. Personnel

The units were asked to tabulate their personnel resources as person-months (FTEs) for each year and for five research staff categories and three assisting personnel categories. The research staff were divided into two subcategories: doctoral and Master's level. The average FTE statistics calculated from this data are shown in Table 4. There are slightly less than 1,300 FTEs overall, of which some 1,000 FTEs are research staff and a further 450 FTEs are doctoral-level research staff. The total FTEs of research and assisting staff for each unit are shown in Figure 2. The largest unit has about 100 FTEs or 8 per cent of total manpower. There are three units with FTEs exceeding 80; for eight units this figure lies between 60 and 80, for ten units it is less than 20, while the remaining units have a FTE number between 20 and 60.

Figures 3 and 4 show a further breakdown of research staff statistics for the units. A "large" unit, in domestic scale, can be defined as having more than 25 doctoral-level researchers, while a "small" unit has no more than five. Thus, there are five large and ten small units. However, it should be kept in mind that there were no unified criteria for selecting the units, so that some of them are departments or divisions, others research groups or assemblies of groups.

Table 4. Average staff FTEs for the units

		Professors	Other senior researchers	Postdoctoral researchers	Total doctoral level	Doctoral students	Other academic staff with MSc	Total master level	Total active research staff	Res. assist. & grad. students	Administrative personnel	Technical personnel	Total assist. admin. & techn.	ALL STAFF
	TOTAL	**102**	**159**	**183**	**444**	**497**	**34**	**531**	**975**	**164**	**47**	**82**	**293**	**1,269**
	Per unit	3	5	6	15	17	1	18	33	5	2	3	10	42
	% of all staff	8	13	14	35	39	3	42	77	13	4	6	23	100
	% of res. staff	10	16	19	45	51	3	54	100					
	% of doctoral	23	36	41	100									
1	AU/Materials	4	9	8	22	31	1	32	54	11	1	3	14	68
2	AU/COMP	7	10	21	38	39	0	39	78	19	1	1	21	99
3	AU/MicroNano	5	6	9	19	28	1	29	48	11	2	0	13	61
4	AU/Optics	1	2	1	4	7	0	7	11	3	1	0	4	15
5	AU/LowTemp	5	6	11	22	20	0	20	42	9	6	5	20	62
6	HIP	3	10	16	29	30	8	38	68	16	6	1	23	91
7	LUT/Physics	2	1	1	3	2	0	2	5	0	1	1	1	6
8	TUT/Aerosol	1	2	1	4	12	0	12	17	6	1	1	8	25
9	TUT/Comp	3	3	4	9	12	0	12	21	3	1	0	3	24
10	TUT/Optics	1	2	2	5	10	0	10	15	4	1	1	6	21
11	TUT/Optoelectr	4	5	8	17	24	1	25	42	13	3	3	19	61
12	UEF/Applied	7	4	13	25	30	3	33	57	3	2	4	10	67
13	UEF/Photonics	6	1	13	20	20	4	24	44	5	2	5	13	56
14	UH/Atmosph	4	6	12	22	35	0	35	57	19	10	3	32	89
15	UH/Particle	7	5	6	18	31	0	31	49	2	0	0	2	51
16	UH/Materials	6	5	8	19	25	0	25	44	10	1	10	21	65
17	UH+FMI/Space	3	20	7	30	7	5	12	42	2	1	4	8	50
18	UJ/Materials	6	10	9	25	32	2	34	59	6	2	7	15	74
19	UJ/Nuclear	6	15	8	29	31	0	31	60	3	2	14	19	79
20	UJ/Particle	2	5	6	13	15	0	15	28	3	1	1	5	33
21	UO/Spectrosc	1	2	2	5	7	0	7	12	4	0	1	5	16
22	UO/Neurobio	1	1	2	4	4	0	4	9	2	0	2	4	12
23	UO/NMR	1	2	2	5	5	0	5	10	1	0	1	2	12
24	UO/Space	2	2	1	5	2	1	3	8	2	0	0	2	9
25	UO/SGO	2	4	6	11	6	4	10	22	4	3	9	17	39
26	UO/Theoretical	1	2	0	3	3	0	3	7	1	0	0	1	7
27	UT/Group1	4	9	4	17	12	1	14	31	1	0	2	3	33
28	UT/Group2	3	7	1	11	6	0	6	16	1	0	2	3	20
29	UT/Group3	1	1	0	2	1	2	4	5	0	0	0	0	6
30	ÅA/Physics	2	2	2	6	11	0	11	16	0	1	2	3	19

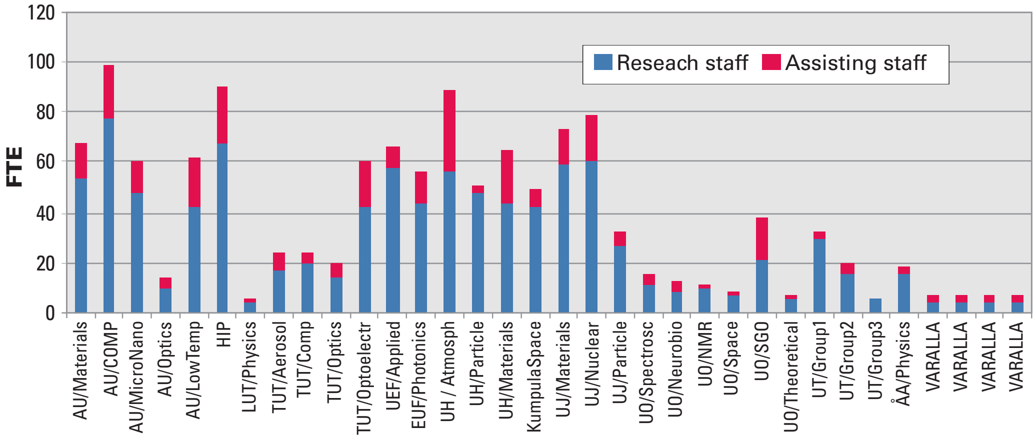

Figure 2. FTEs for research staff and assisting staff

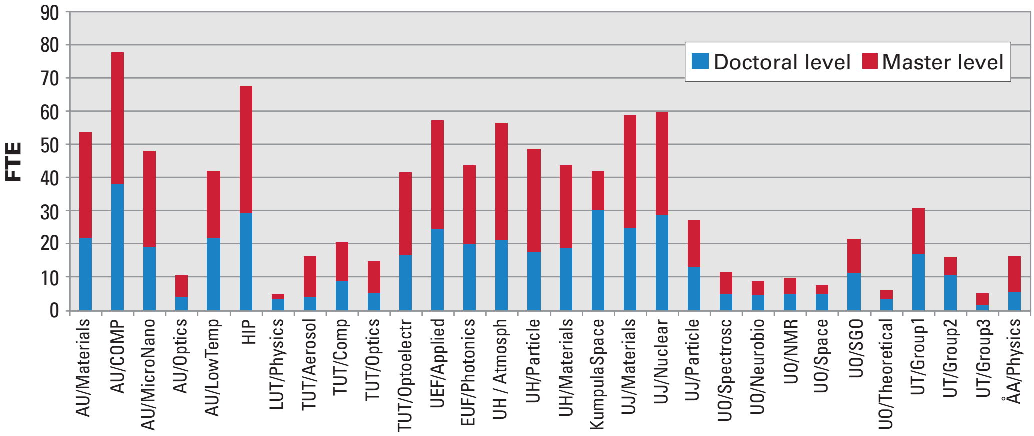

Figure 3. FTEs for doctoral- and Master's-level researchers

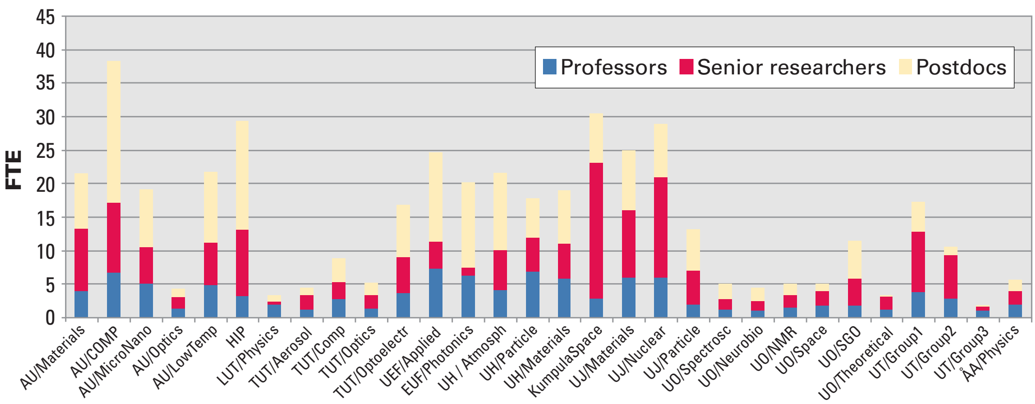

Figure 4. Doctoral-level researcher FTEs, divided between professors, postdoctoral researchers and other senior researchers

During the five-year evaluation period, there has been a steady increase in research staff while the number of assisting personnel has not changed much (Table 4, Figures 5 and 6). The increase is mostly attributable to postdoctoral researchers, the number of whom has increased by 58 per cent. The division of physics research manpower between the universities and special institutes is shown in Figure 7. It shows that the resources of HIP are comparable to those of smaller universities.

The units were also asked to list doctoral-level researchers who have worked in the unit during the evaluation period. The total number, 851, is about twice as much as the average FTE. This agrees with the average stay in the unit during the five-year evaluation period, which is somewhat more than three years. The field of physics is male-dominated, with four-fifths being men, and the average age of obtaining a PhD degree is 32. The doctoral level is also international, as 28 per cent got their PhD

Table 5. Changes in FTEs during the evaluation period

FTE	2007	2008	2009	2010	2011	Increase % 2007–2011
Professors	97	99	108	104	106	7
Senior researchers	144	159	155	165	169	7
Postdoctorals	145	155	174	201	239	58
All doctoral-level staff	386	413	437	470	514	26
Postgraduates	459	469	519	512	522	12
Other academic staff	39	35	33	35	30	-13
Postgrads & other ac.	497	503	552	547	552	10
All research staff	883	916	989	1,016	1,066	17
Assistants & grad.stud.	161	163	163	162	173	6
Administrative staff	43	46	52	48	47	1
Technical staff	87	83	80	76	77	-7
Total assisting staff	290	292	295	286	297	2
All staff	1,173	1,208	1,284	1,302	1,363	13

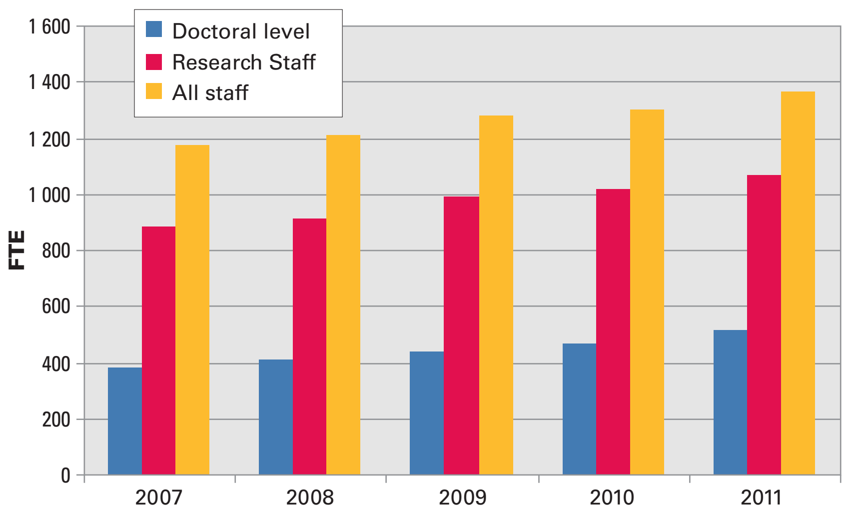

Figure 5. Changes in FTEs during the evaluation period

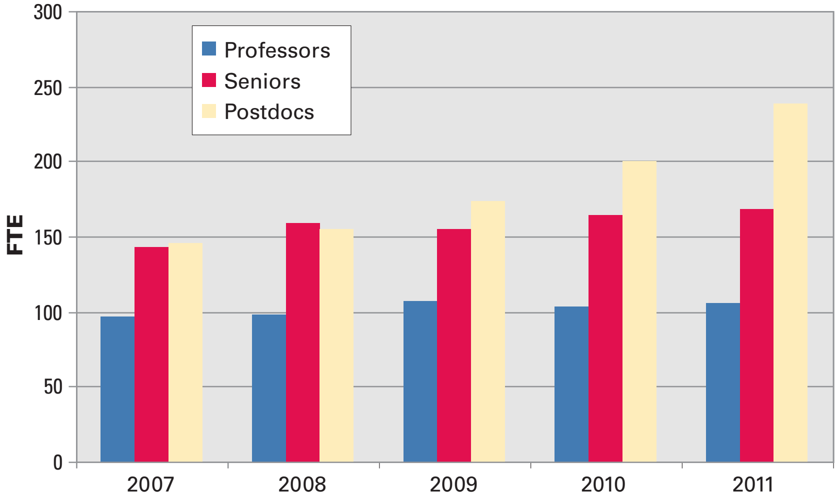

Figure 6. Changes in doctoral-level research staff FTEs during the evaluation period

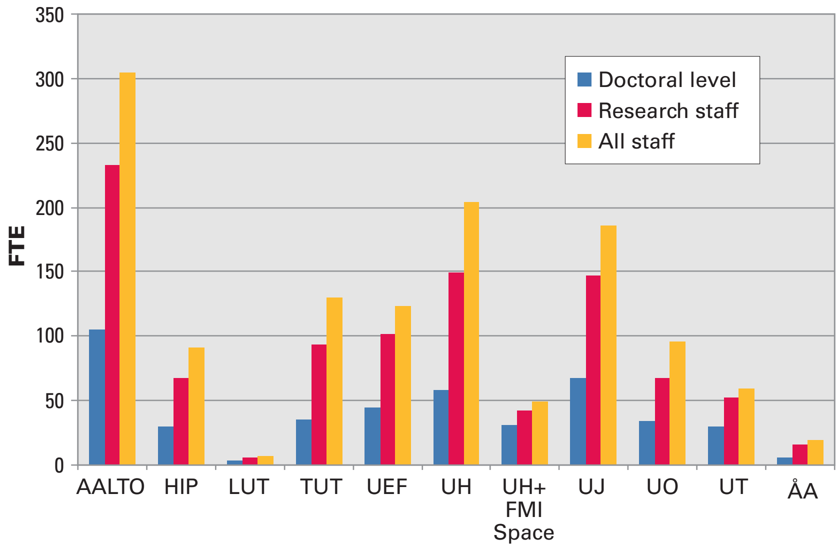

Figure 7. Staff FTEs at universities, HIP and the Kumpula Space Centre (UH+FMI/Space)

degree from foreign universities. Moving between Finnish universities is, on the other hand, not so common, as 59 per cent of the doctoral-level researchers were educated at the same university.

There is one professor for every five doctoral-level researchers and they are about ten years older than the overall average age at the doctoral level. On average, professors get their PhDs at the age of 29, which is three years earlier than the overall averages. A standard professor is 54 years old and got his/her PhD degree 25 years ago. The distribution of the year of getting the PhD is shown in Figure 8 for professors. It has a clear bimodal appearance, with modes for early the 1980s and early 1990s.

Table 6. Statistics on doctoral-level researchers

Number of doctoral-level researchers	857
Percentage of men	86
Researchers per FTE	1.93
Average year of birth	1968
Professors %	19
Senior scientists and lecturers %	35
Postdoctoral researchers %	46
Degree awarded by % same university	59
% other Finnish	14
% foreign university	28
Year awarded	2000
Years stayed in the unit during the evaluation period	3.2
Age of obtaining PhD	32

Table 7. Statistics on professors

Number of professors	159
Percentage of men	93
Professors per FTE	1.5
Average year of birth	1958
Degree awarded by % same university	58
% other Finnish	23
% foreign university	19
Year awarded	1987
Years stayed in the unit during the evaluation period	4.3
Age of obtaining PhD	29

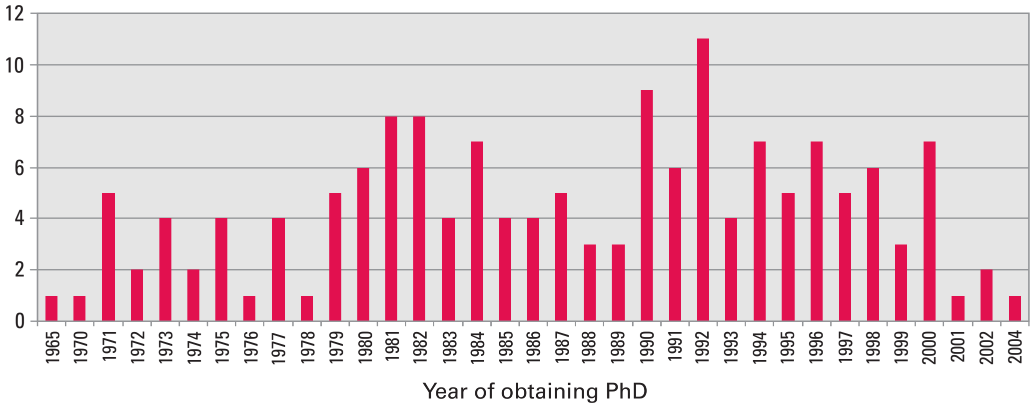

Figure 8. Year of obtaining PhD degree (professors)

Senior researches, which here includes university lecturers, have about double the manpower in comparison with professors. Their age of obtaining the PhD degree is 39. A possible reason is that, during recent years, older staff with senior responsibilities but no PhD have been encouraged to rectify this state of matters. The percentage of degrees from foreign universities is quite low both for professors and senior researchers.

Postdoctoral researchers are the largest category. They even have a more international profile, as more than one-third of them have a degree from a foreign university. However, the age of obtaining a PhD (31) is about the same as the overall value. Thus, it appears that the efficiency of PhD studies has not really changed in comparison to the postgraduate years of present professors, but this indicates rather that the style of pursuing career in physical research has not changed much. The percentage of men, 81 per cent, is lower than the overall value, but not much. The transition away from a male dominance is slow, or there is no such transition.

The universities that have awarded PhD degrees to professors are listed in Table 10. These are not concentrated to any particular universities.

The units were asked to provide person-month statistics for visiting researchers in all research staff categories, as well as a list of visiting doctoral-level researchers. The criterion was that the funding was arranged by the unit. As concerns the statistics of individual units, these data are quantitatively not very reliable, as there

Table 8. Statistics on senior researchers

Number of seniors and lecturers		282
Percentage of men		86
Researchers per FTE		0.56
Average year of birth		1960
Degree awarded by	% same university	66
	% other Finnish	11
	% foreign university	23
Year awarded		1999
Age of obtaining PhD		39

Table 9. Statistics on postdoctoral researchers

Number of postdoctoral researchers		362
Percentage of men		81
Researchers per FTE		0.51
Average year of birth		1976
Degree awarded by	% same university	56
	% other Finnish	10
	% foreign university	34
Year awarded		2007
Age of obtaining PhD		31

apparently were several interpretations of the instructions. Also, the units' own criteria on visit duration and on which cases count as "visiting researchers" and which merely as "visits to the unit" varied. Thus, unit comparisons are not shown. Some statistics not so much affected by these reservations are listed in Tables 11–13. The tables show that most stays of visiting researchers were short and only 4 per cent of them lasted one year or longer.

Table 10. Foreign universities that have awarded PhD degrees to present professors (if there are several degrees, the number is shown)

A.F. Ioffe Physical-Technical Institute of the Academy of Sciences of USSR, St. Petersburg	University of Liverpool
Brown University	University of Rochester, NY, USA (4)
California Institute of Technology	University of Southern California (2)
Kemerovo State University	University of Stony Brook
Landau Institute for Theoretical Physics (2)	University of Sussex UK
Moscow State University (2)	University of Twente, Netherlands
P.N. Lebedev Physical Institute, Academy of Sciences, Moscow	University of Ulm
State University of New York at Stony Brook	University of Warsaw
University College London (2)	University of Bayreuth, Germany
University of Durham	Uppsala University
University of Aberdeen	VRIJE University Amsterdam
University of Amsterdam	

Table 11. Visiting researcher statistics

Number of visiting researchers	983
Percentage of men	88
Professors %	44
Senior scientists and lecturers %	46
Postdoctoral researchers %	10
Period stayed in the unit, days	59

Table 12. Duration of visits

Longer than one year	44
3 months–1 year	84
1 month –3 months	151
1 week–1 month	195
1 day–1 week	445

Table 13. Country of origin for 44 visiting researchers who stayed for one year or longer

USA	8	Brazil	1	Netherlands	1
Finland	5	Cameroon	1	Poland	1
Germany	5	Canada	1	Spain	1
Denmark	3	China	1	Switzerland	1
Estonia	3	Czech Republic	1	Turkey	1
Russia	2	France	1	UK	1
Sweden	2	Greece	1		
Ukraine	2	Japan	1		

A5. Funding

The overall funding for the evaluation period was about EUR 90 million per year, of which core funding accounted for 42 per cent. The average funding per unit was EUR 2.6 million per year. The largest source of external funding, with 22 per cent of total funding, was the Academy of Finland, while Tekes funding accounted for 11 per cent or for slightly more than EU funding (9%) (see Table 14 and Figure 9). Tables 15–17 show unit details on funding categories and the unit funding profiles are compared in Figures 10–12. The data show that the range of external funding is 15–90 per cent and the range of Academy funding is 3–62 per cent. The highest Tekes percentages, 45 per cent and 41 per cent, are for space physics and aerosol physics. The overall EU funding percentage is raised by the fact that one unit, UH/Atmosph, received about 40 per cent of the total EU funding and covered 36 per cent of its budget with that funding.

Table 14. Overall funding and funding categories for the evaluation period

K€	Evaluation period	Per year	%	Evaluation period per unit	Per unit per year
Budget	171,003	34,201	38	5,029	1,006
Other core	21,372	4,274	5	629	126
Total core	192,375	38,475	43	5,658	1,132
Academy	98,093	19,619	22	2,885	577
Min.Edu.	15,574	3,115	3	458	92
Tekes	48,252	9,650	11	1,419	284
Public	13,115	2,623	3	386	77
Industry	20,917	4,183	5	615	123
Foundations	10,356	2,071	2	305	61
EU	41,751	8,350	9	1,228	246
Other foreign	9,039	1,808	2	266	53
Total external	257,097	51,419	57	7,562	1,512
Total overall	449,711	89,942	100	13,227	2,645

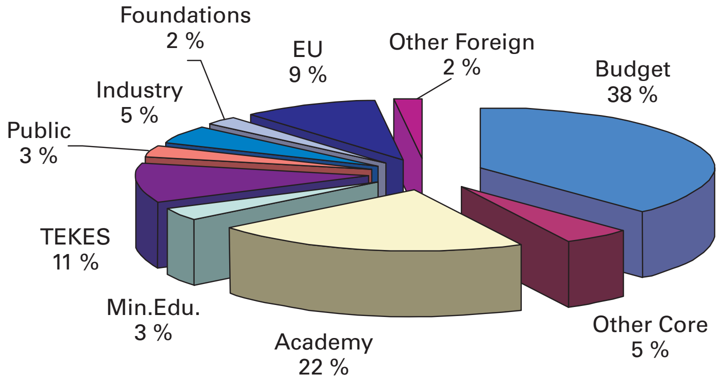

Figure 9. Proportion of different funding categories

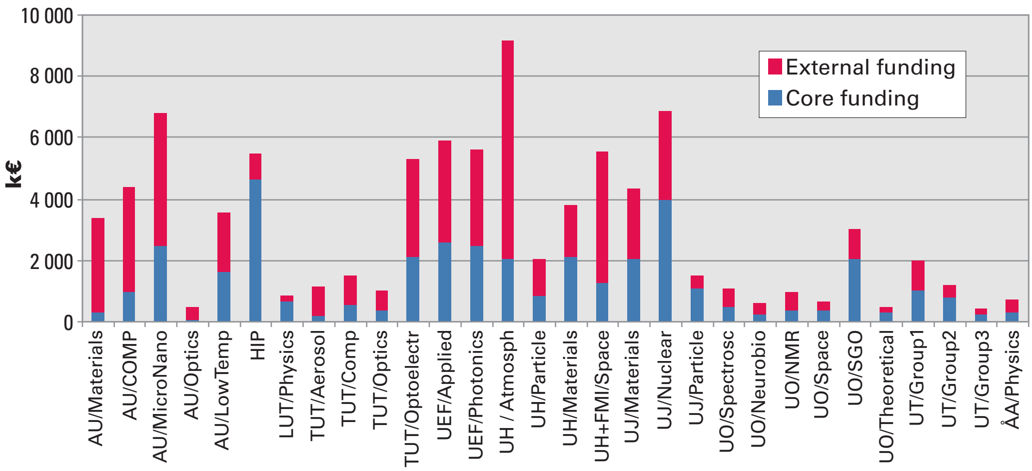

Figure 10. Total, external and core funding for units (average per year)

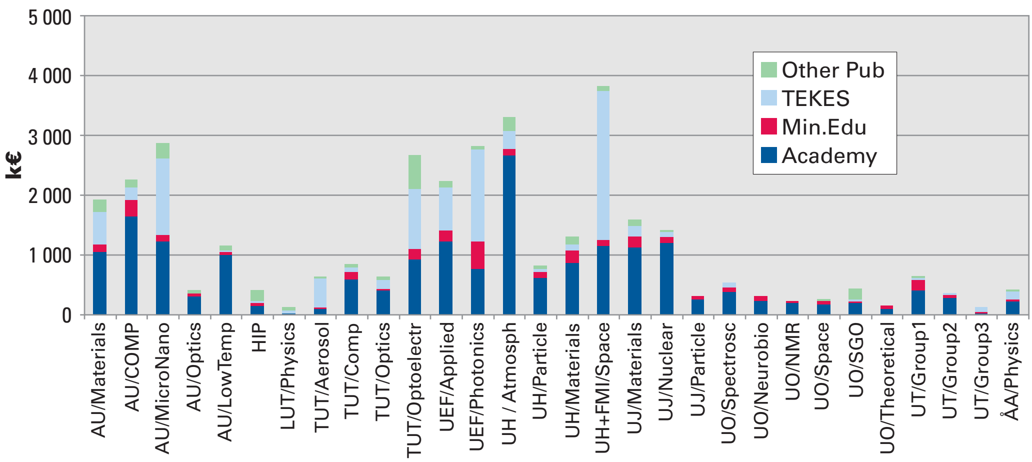

Figure 11. External funding categories for units (Part 1)

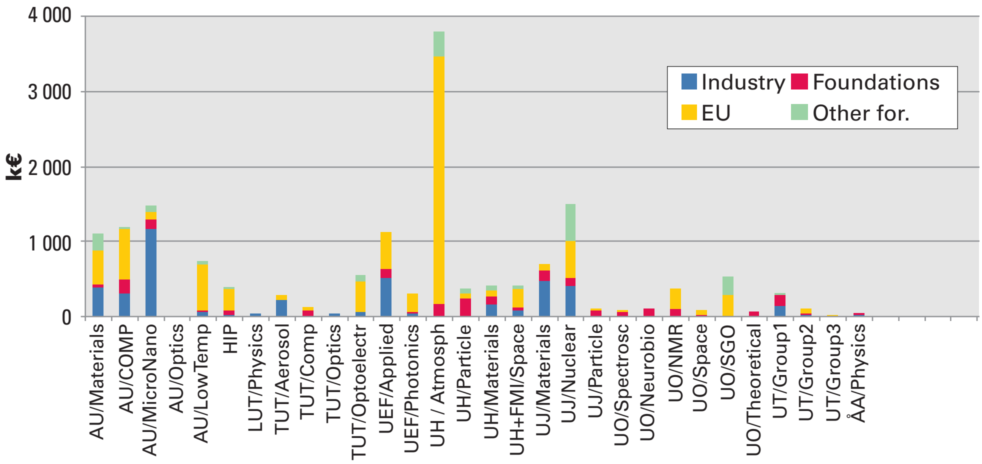

Figure 12. External funding categories for units (Part 2)

Table 15. Total, core and external funding for units (per year average)

		Total core		Total external		Total overall
		k€	%	k€	%	k€
1	AU/Materials	329	10	3,039	90	3,368
2	AU/COMP	962	22	3,434	78	4,395
3	AU/MicroNano	2,468	36	4,343	64	6,811
4	AU/Optics	90	18	400	82	490
5	AU/LowTemp	1,652	47	1,878	53	3,529
6	HIP	4,668	85	792	15	5,460
7	LUT/Physics	655	79	170	21	826
8	TUT/Aerosol	207	18	940	82	1,147
9	TUT/Comp	523	35	971	65	1,494
10	TUT/Optics	353	34	674	66	1,027
11	TUT/Optoelectr	2,081	39	3,240	61	5,320
12	UEF/Applied	2,562	43	3,369	57	5,932
13	EUF/Photonics	2,468	44	3,134	56	5,602
14	UH/Atmosph	2,067	23	7,112	77	9,179
15	UH/Particle	848	42	1,195	58	2,043
16	UH/Materials	2,084	55	1,722	45	3,806
17	UH+FMI/Space	1,294	23	4,223	77	5,518
18	UJ/Materials	2,022	47	2,288	53	4,310
19	UJ/Nuclear	3,967	58	2,903	42	6,871
20	UJ/Particle	1,076	72	423	28	1,499
21	UO/Spectrosc	483	44	625	56	1,108
22	UO/Neurobio	213	34	414	66	627
23	UO/NMR	368	38	604	62	972
24	UO/Space	337	50	337	50	675
25	UO/SGO	2,073	68	956	32	3,029
26	UO/Theoretical	271	54	227	46	498
27	UT/Group1	1,022	52	958	48	1,979
28	UT/Group2	772	63	458	37	1,230
29	UT/Group3	243	61	159	39	402
30	ÅA/Physics	315	42	432	58	748
	TOTAL	38,475	43	51,419	57	89,942

Table 16. External funding categories for units (per year average, Part 1)

		Academy		Min.Edu.		Tekes		Other public	
		k€	%	k€	%	k€	%	k€	%
1	AU/Materials	1,058	31	128	4	526	16	213	6
2	AU/COMP	1,633	37	278	6	213	5	124	3
3	AU/MicroNano	1,235	18	90	1	1,293	19	246	4
4	AU/Optics	304	62	66	13	0	0	30	6
5	AU/LowTemp	991	28	71	2	11	0	68	2
6	HIP	160	3	48	1	28	1	171	3
7	LUT/Physics	33	4	0	0	43	5	52	6
8	TUT/Aerosol	108	9	30	3	466	41	46	4
9	TUT/Comp	595	40	113	8	85	6	58	4
10	TUT/Optics	398	39	38	4	164	16	29	3
11	TUT/Optoelectr	916	17	194	4	988	19	579	11
12	UEF/Applied	1,238	21	173	3	723	12	100	2
13	EUF/Photonics	762	14	458	8	1,552	28	56	1
14	UH/Atmosph	2,671	29	90	1	319	3	227	2
15	UH/Particle	605	30	124	6	32	2	66	3
16	UH/Materials	875	23	208	5	84	2	136	4
17	UH+FMI/Space	1,153	21	109	2	2,478	45	76	1
18	UJ/Materials	1,136	26	169	4	182	4	95	2
19	UJ/Nuclear	1,207	18	109	2	81	1	3	0
20	UJ/Particle	267	18	44	3	0	0	0	0
21	UO/Spectrosc	396	36	71	6	71	6	0	0
22	UO/Neurobio	239	38	79	13	0	0	0	0
23	UO/NMR	196	20	32	3	0	0	2	0
24	UO/Space	188	28	35	5	0	0	37	5
25	UO/SGO	203	7	24	1	38	1	166	5
26	UO/Theoretical	112	23	50	10	0	0	0	0
27	UT/Group1	415	21	180	9	32	2	18	1
28	UT/Group2	270	22	60	5	28	2	0	0
29	UT/Group3	38	9	15	4	86	21	0	0
30	ÅA/Physics	218	29	26	3	128	17	26	3
		19,619	22	3,115	3	9,650	11	2,623	3

Table 17. External funding categories for units (per year average, Part 2)

		Industry		Foundations		EU		Other foreign	
		k€	%	k€	%	k€	%	k€	%
1	AU/Materials	387	11	43	1	461	14	222	7
2	AU/COMP	298	7	193	4	670	15	25	1
3	AU/MicroNano	1,179	17	114	2	95	1	91	1
4	AU/Optics	0	0	0	0	0	0	0	0
5	AU/LowTemp	63	2	21	1	622	18	30	1
6	HIP	18	0	66	1	281	5	19	0
7	LUT/Physics	38	5	0	0	2	0	1	0
8	TUT/Aerosol	231	20	1	0	47	4	12	1
9	TUT/Comp	3	0	74	5	36	2	7	0
10	TUT/Optics	35	3	10	1	0	0	0	0
11	TUT/Optoelectr	53	1	0	0	412	8	98	2
12	UEF/Applied	512	9	134	2	474	8	16	0
13	EUF/Photonics	46	1	8	0	252	4	0	0
14	UH/Atmosph	0	0	155	2	3,306	36	343	4
15	UH/Particle	0	0	238	12	64	3	66	3
16	UH/Materials	170	4	93	2	93	2	64	2
17	UH+FMI/Space	74	1	58	1	244	4	31	1
18	UJ/Materials	478	11	135	3	94	2	0	0
19	UJ/Nuclear	408	6	114	2	482	7	500	7
20	UJ/Particle	0	0	90	6	22	1	0	0
21	UO/Spectrosc	3	0	63	6	19	2	2	0
22	UO/Neurobio	0	0	96	15	0	0	0	0
23	UO/NMR	0	0	100	10	270	28	4	0
24	UO/Space	1	0	14	2	59	9	4	1
25	UO/SGO	0	0	0	0	277	9	247	8
26	UO/Theoretical	0	0	64	13	0	0	0	0
27	UT/Group1	149	8	143	7	0	0	22	1
28	UT/Group2	19	2	29	2	52	4	0	0
29	UT/Group3	0	0	3	1	15	4	2	1
30	ÅA/Physics	20	3	14	2	0	0	0	0
		4,183	5	2,071	2	8,350	9	1,808	2

The funding divided by personnel FTEs, both for total staff and for research staff, is shown in Figure 13. The overall averages are EUR 70,000 per staff FTE and EUR 92,000 per research staff FTE. However, the various research profiles and the different infrastructure intensities should be kept in mind when comparing these figures.

The development of funding during the evaluation period is shown in Tables 18 and 19 and in Figures 14–16. The overall funding has been steadily increasing, which is thanks to external funding. The core funding percentage has dropped from 49 to 37 per cent. In external funding, Academy funding has increased from 16 to 27 per cent, while Tekes

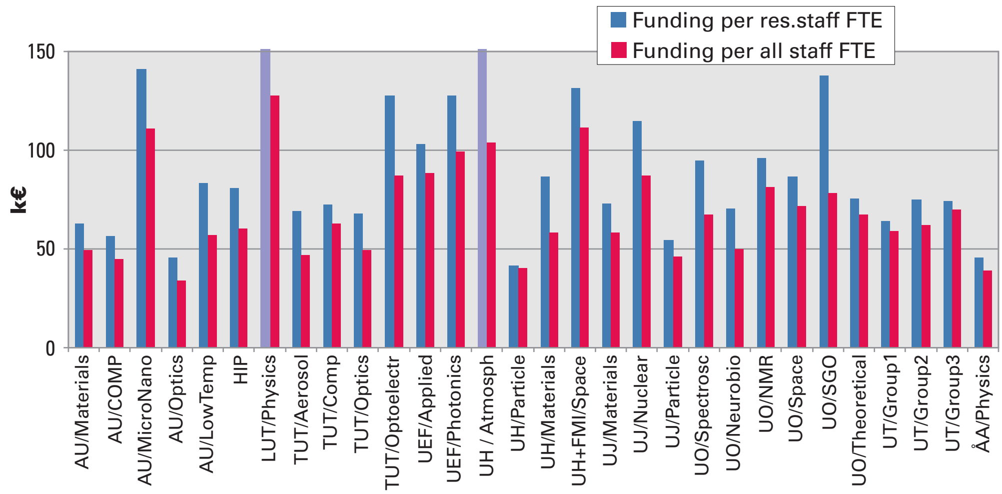

Figure 13. Funding per research staff FTE and per total staff FTE

Table 18. Changes in funding during the evaluation period

K€	2007	2008	2009	2010	2011	Total
Budget	31,668	34,236	34,373	34,813	35,913	171,003
Other core	3,114	4,272	5,246	3,925	4,815	21,372
Total core	34,782	38,508	39,619	38,738	40,728	192,375
Academy	11,759	14,579	18,508	23,372	29,874	98,093
Min.Edu.	2,798	2,893	3,214	3,340	3,332	15,574
Tekes	8,610	8,460	9,434	10,287	11,461	48,252
Public	2,291	2,168	3,562	2,687	2,407	13,115
Industry	3,539	4,060	4,916	4,499	3,903	20,917
Foundations	1,951	2,051	2,221	2,023	2,109	10,356
EU	4,202	4,224	7,932	10,443	14,950	41,751
Other foreign	1,477	1,549	1,776	1,711	2,525	9,039
Total external	36,627	39,984	51,564	58,361	70,562	257,097
Total overall	71,408	78,493	91,183	97,099	111,289	449,711
From prev. year %		10	16	6	15	
From year 2007 %		11	29	37	57	

funding has kept its level around 10 per cent. The doubling of EU funding is largely thanks to one unit, UH/Atmosph. There are different histories in the funding development of the units, but, generally, larger units have been able to increase their funding faster. There are also a number of smaller units showing no increase or a slight decrease during the evaluation period.

Table 19. Changes in funding percentages during the evaluation period

	2007	2008	2009	2010	2011
Budget	44	44	38	36	32
Other core	4	5	6	4	4
Total core	49	49	43	40	37
Academy	16	19	20	24	27
Min.Edu.	4	4	4	3	3
Tekes	12	11	10	11	10
Public	3	3	4	3	2
Industry	5	5	5	5	4
Foundations	3	3	2	2	2
EU	6	5	9	11	13
Other foreign	2	2	2	2	2
Total external	51	51	57	60	63
Total overall	100	100	100	100	100

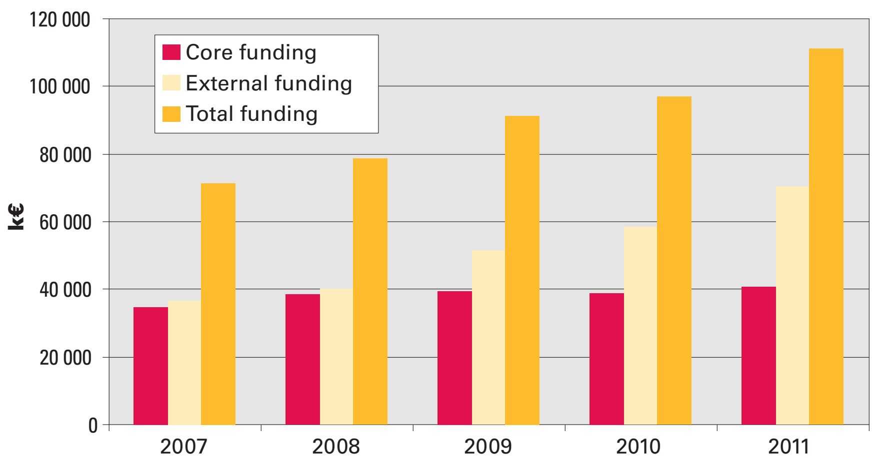

Figure 14. Development of total, core and external funding during the evaluation period

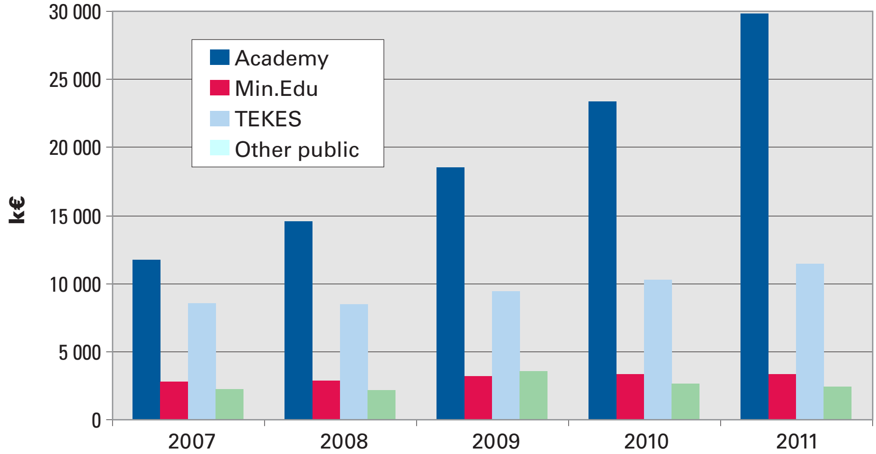

Figure 15. Development of external funding categories during the evaluation period (Part 1)

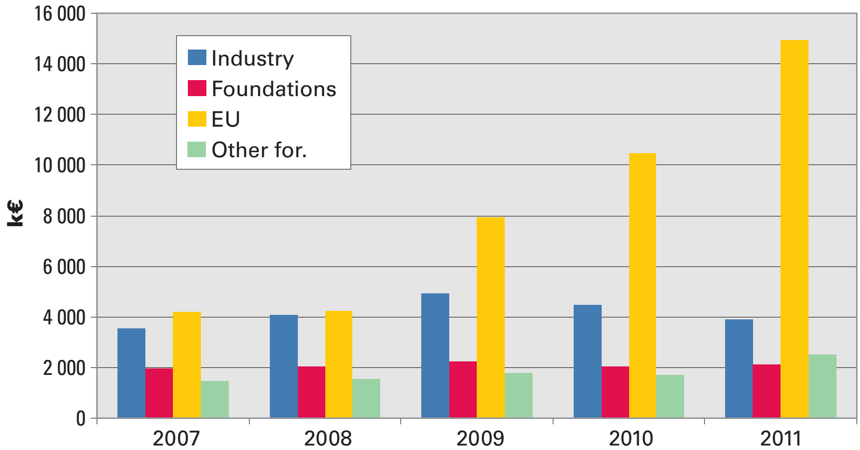

Figure 16. Development of external funding categories during the evaluation period (Part 2)

A6. Research output

The units were asked to provide statistics on publication activity for journal articles and proceeding articles, as well as statistics on patents. These data are summarised in Table 20 and in Figures 17 and 18. In total, there were some 8,000 journal articles produced during the evaluation period, on average slightly more than 250 per unit, while the most productive unit (HIP) had more than 900. The number of patents or invention disclosures during the evaluation period was 160, about six per unit, which is considerably increased by the 40 patents and disclosures of UEF/Applied.

Table 20. Number of publications and other research outputs

		Journal articles	Other reviewed articles	Non-refereed articles	Scientific books	Other professional	Granted patents	Invention disclosures	Audiovisual, software	Other
1	AU/Materials	362	21	377	0	1	8	3	0	0
2	AU/COMP	499	54	38	6	2	0	6	5	29
3	AU/MicroNano	262	150	0	2	0	5	5	1	0
4	AU/Optics	117	5	0	0	0	1	0	0	0
5	AU/LowTemp	257	28	14	0	2	1	5	0	0
6	HIP	920	148	36	3	10	1	0	0	0
7	LUT/Physics	172	26	0	0	0	0	0	0	0
8	TUT/Aerosol	56	93	0	0	0	2	11	0	0
9	TUT/Comp	230	107	0	0	0	0	0	2	0
10	TUT/Optics	71	191	0	0	0	0	8	0	0
11	TUT/Optoelectr	230	233	123	1	5	1	7	0	13
12	UEF/Applied	518	191	0	0	1	33	12	1	1
13	EUF/Photonics	293	191	0	2	0	0	0	0	130
14	UH/Atmosph	628	860	2	7	40	4	3	14	9
15	UH/Particle	553	45	7	2	12	0	0	0	21
16	UH/Materials	491	51	104	2	13	1	14	1	2
17	UH+FMI/Space	352	26	67	12	67	1	0	0	0
18	UJ/Materials	299	34	30	0	18	6	4	3	0
19	UJ/Nuclear	426	104	65	2	3	6	0	1	0
20	UJ/Particle	190	66	3	0	23	0	0	7	4
21	UO/Spectrosc	114	4	74	0	1	0	1	0	0
22	UO/Neurobio	28	15	0	1	0	0	4	0	0
23	UO/NMR	39	3	2	1	1	1	1	1	1
24	UO/Space	72	3	23	0	9	0	0	8	2
25	UO/SGO	163	4	239	4	0	2	0	1	0
26	UO/Theoretical	62	5	0	0	0	0	0	0	0
27	UT/Group1	256	26	2	0	6	0	0	0	0
28	UT/Group2	133	31	7	2	0	1	0	0	0
29	UT/Group3	26	8	8	0	1	0	0	0	0
30	ÅA/Physics	86	10	10	0	2	1	2	0	0
	TOTAL	**7,905**	**2,733**	**1,231**	**47**	**217**	**75**	**86**	**45**	**212**
	Per unit	**264**	**91**	**41**	**2**	**7**	**3**	**3**	**2**	**7**
	Per unit per year	**52.7**	**18.2**	**8.2**	**0.3**	**1.4**	**0.5**	**0.6**	**0.3**	**1.4**
	Per doctoral FTE year	**3.54**	**1.23**	**0.55**	**0.02**	**0.10**	**0.03**	**0.04**	**0.02**	**0.10**
	Per res. FTE year	**1.61**	**0.56**	**0.25**	**0.01**	**0.04**	**0.02**	**0.02**	**0.01**	**0.04**

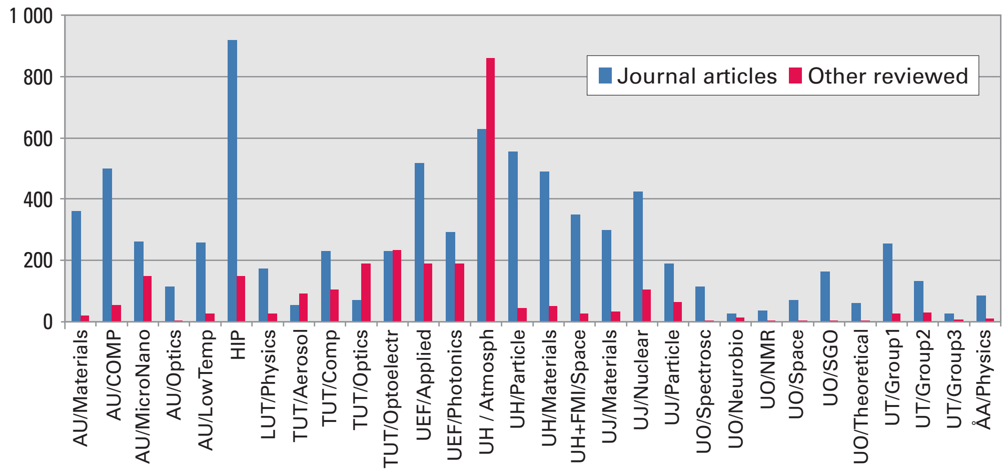

Figure 17. Number of journal articles and other reviewed publications in the evaluation period

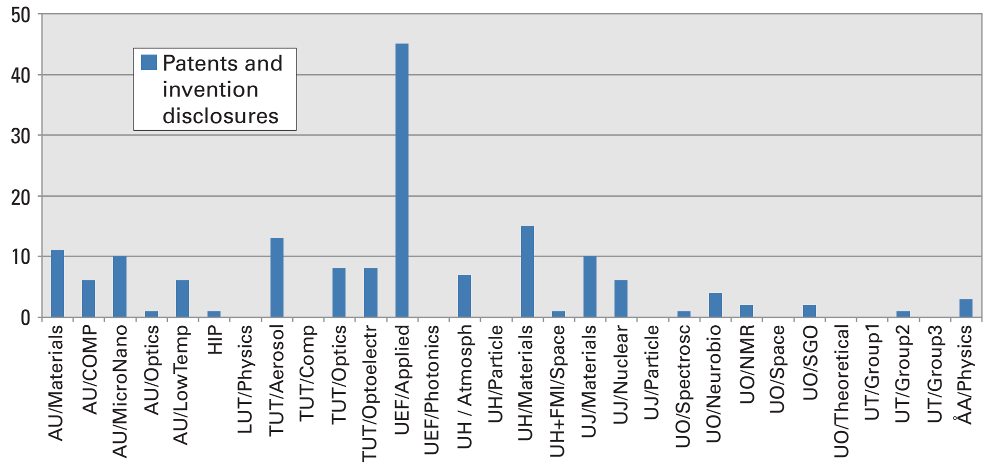

Figure 18. Number of patents and invention disclosures in total

In addition to the 1,600 journal articles per year, there were 540 other refereed publications and 250 non-refereed publications per year. However, the numbers in these categories vary much between units, as some units have apparently not considered this data worth collecting. Thus, the efficiency of journal article production only is considered in Figures 19 and 20. A division by personnel resources yields 3.5 articles per doctoral-level FTE per year, and 1.6 articles per researcher per year. There are six units producing five or more articles per doctoral-level FTE per year, while for another six units this figure is 2.5 or less. Dividing the total funding by journal article production gives a “k€/paper”

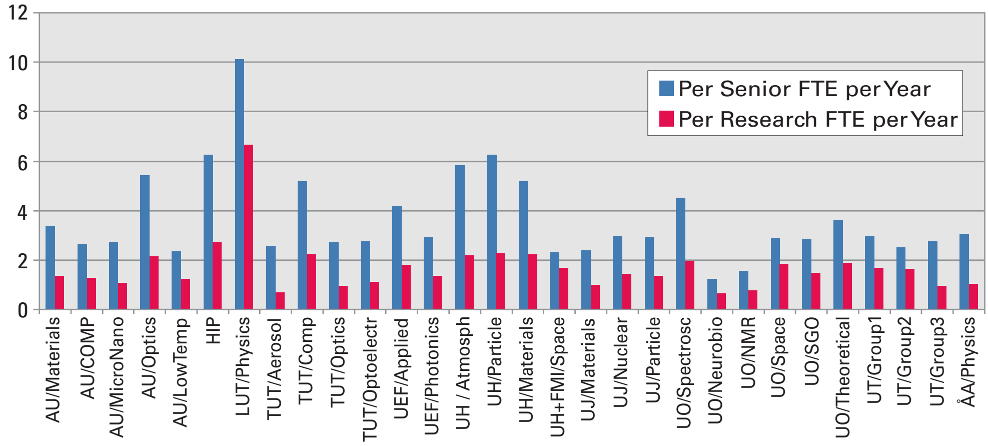

Figure 19. Publication efficiency I: Journal articles per doctoral-level FTE per year, and per research FTE per year

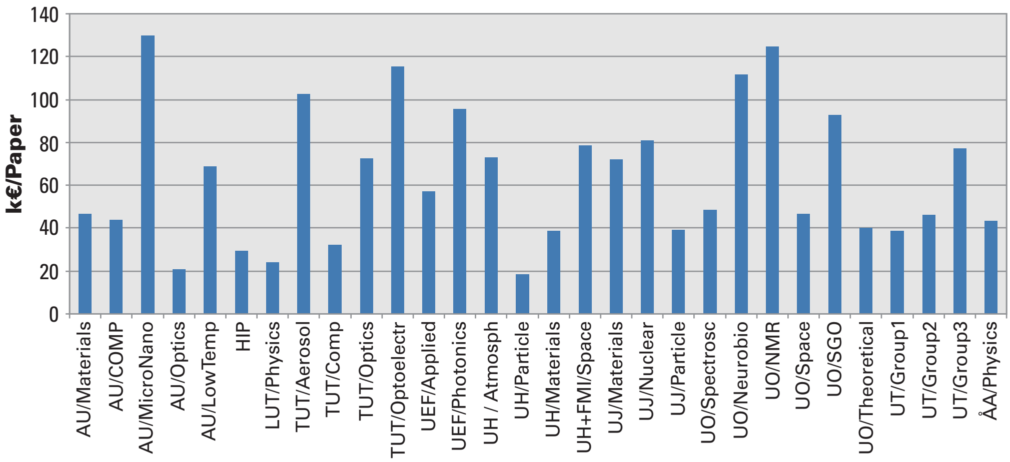

Figure 20. Publication efficiency II: Total funding divided by the number of journal articles (k€/paper)

descriptor that has a mean value of 57. Different research profiles and infrastructure intensities should be kept in mind, however.

The increase in article production in Figure 21 roughly follows the increase in research staff, and there are no clear trends in publication efficiency. As a measure of internationalisation, the statistics of foreign co-authors was also asked (Figure 22). There are on average about two articles with a foreign collaboration per one purely domestic article. The overall ratio rose from 1.8 to 2.4 during the evaluation period and is about five to one for fields such as particle physics, space physics and computational physics.

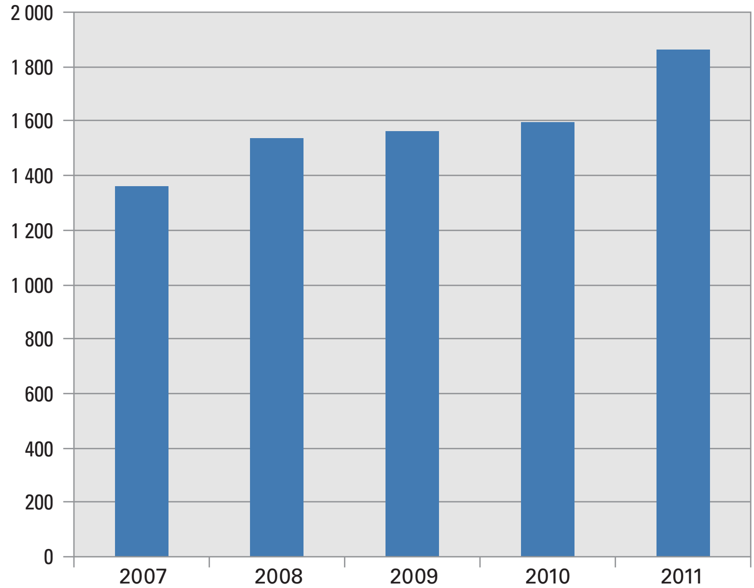

Figure 21. Development of total number of journal articles per year

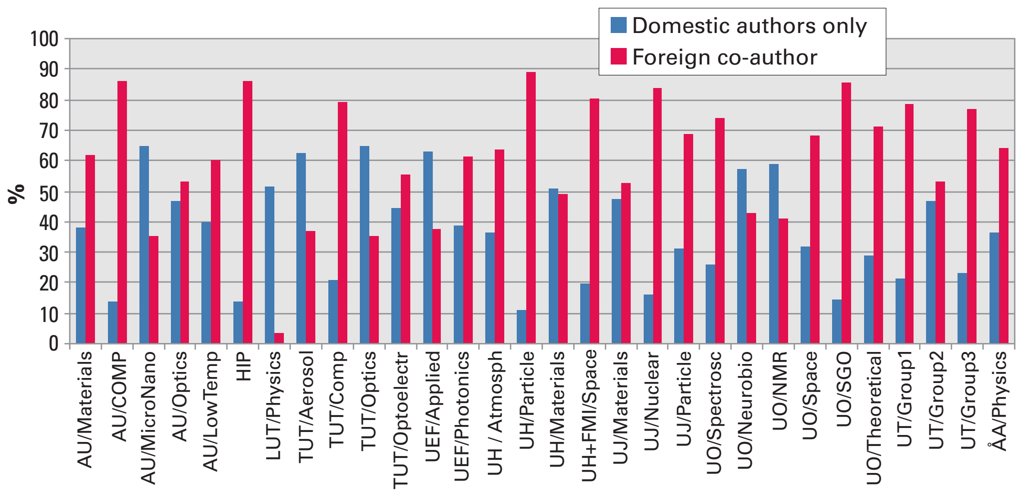

Figure 22. Percentages for co-authoring categories

A7. Education

The data on degree production, number of postgraduate students and PhD degrees are collected in Table 21. There were in total slightly more than 200 Master's degrees and about 100 PhD degrees per year, so the ratio is two to one but is for some units much higher, as seen in Figure 23. There were on average 1.9 MSc and 0.9 PhD degrees per professor FTE. No significant change in degree production was seen during the evaluation period (Figure 24).

Table 21. Degree production (averages per year) and data on PhD degrees

		Master's degree	Postgraduate students	Full-time postgraduates	PhD degree	MScs per one PhD	Postgraduates per one PhD	% of men of PhD degrees	Av. year of birth PhD degs	Years to complete PhD	Years in unit during PhD std
1	AU/Materials	2.8	28.6	27.2	4.4	0.6	6.5	84	1980	4	4
2	AU/COMP	10.0	37.2	0.0	7.0	1.4	5.3	85	1979	5	5
3	AU/MicroNano	7.8	39.0	34.0	6.0	1.3	6.5	91			
4	AU/Optics	2.2	9.8	7.8	2.0	1.1	4.9	89	1981	4	4
5	AU/LowTemp	2.8	20.0	20.0	2.0	1.4	10.0	100	1975	7	3
6	HIP	12.0	36.2	30.1	8.4	1.4	4.3	79		5	4
7	LUT/Physics	10.6	0.0	0.0	1.8	5.9	0.0	78	1979	4	4
8	TUT/Aerosol	4.8	12.6	12.6	0.6	8.0	21.0	100	1977	5	4
9	TUT/Comp	4.6	11.8	11.8	1.6	2.9	7.4	88	1977	6	6
10	TUT/Optics	5.4	11.2	11.2	1.4	3.9	8.0	100	1978	4	4
11	TUT/Optoelectr	6.4	28.2	27.0	3.8	1.7	7.4	95	1979	4	4
12	UEF/Applied	10.2	56.4	29.8	9.0	1.1	6.3	74	1979	5	5
13	EUF/Photonics	7.4	24.6	21.8	4.2	1.8	5.9	81	1980	5	5
14	UH/Atmosph	17.4	61.6	34.2	7.8	2.2	7.9	49	1980	4	4
15	UH/Particle	8.4	34.8	30.2	6.0	1.4	5.8	83	1977	5	5
16	UH/Materials	12.0	27.2	24.6	7.2	1.7	3.8	75	1976	5	4
17	UH+FMI/Space	2.0	6.6	6.6	1.6	1.3	4.1	75	1978	5	5
18	UJ/Materials	20.6	35.2	31.8	4.6	4.5	7.7	87	1975	7	3
19	UJ/Nuclear	12.4	33.4	31.4	5.0	2.5	6.7	84	1979	4	4
20	UJ/Particle	6.4	13.6	13.0	2.8	2.3	4.9	93	1978	5	5
21	UO/Spectrosc	4.0	8.6	7.6	2.0	2.0	4.3	71	1976	5	5
22	UO/Neurobio	4.2	4.8	4.6	0.6	7.0	8.0	100	1979	6	6
23	UO/NMR	1.4	7.3	4.9	1.2	1.2	6.1	67	1977	5	5
24	UO/Space	2.8	5.8	3.0	0.8	3.5	7.3	100	1976	6	4
25	UO/SGO	0.0	1.2	0.8	0.0				1981	5	4
26	UO/Theoretical	4.2	7.6	7.6	1.4	3.0	5.4	100	1972	6	6
27	UT/Group1	12.0	21.0	14.6	2.0	6.0	10.5	70	1978	8	6
28	UT/Group2	6.4	18.4	15.2	1.8	3.6	10.2	78	1978	6	4
29	UT/Group3	2.4	10.6	2.4	0.2	12.0	53.0	100			
30	ÅA/Physics	3.4	13.0	11.0	1.4	2.4	9.3	100	1977	6	5
	Total or average	207	626	476	99	2.1	6.4		1977		
	Per unit	6.9	20.9	15.9	3.3	2.1	6.4				

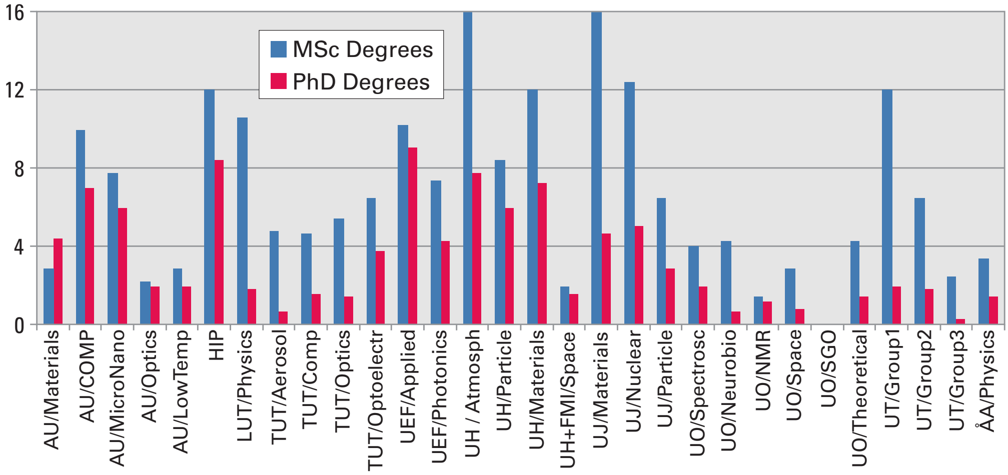

Figure 23. Degree production in units (averages per year)

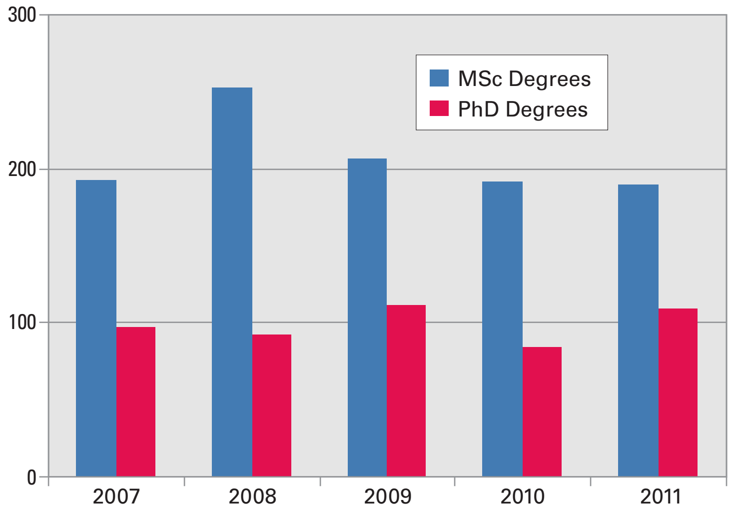

Figure 24. Development of degree production during the evaluation period

The units were also asked to list their doctoral dissertations during the evaluation period. There were in all 480 doctoral dissertations, of which 81 per cent were by men (the percentage is the same as for postdoctoral researchers). The male dominance is thus solid and it is also consistently found for all units, the only exception being the 50/50 balance for UH/Atmosph. On average, postgraduate studies took somewhat more than five years, of which 4.5 years were spent in the unit. The average year of birth was 1977. The corresponding distributions are listed in Figures 25 and 26.

The present employment was reported in 464 cases (Figure 27). Of the new PhDs, 72 per cent continued their research career at universities and in research institutes, 43 per cent in Finland and 29 per cent in other countries. This includes five professors, all

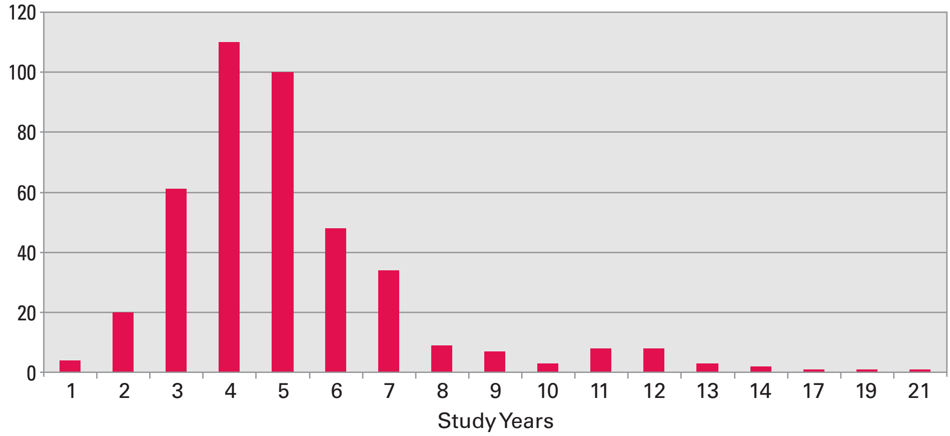

Figure 25. Years used for postgraduate studies

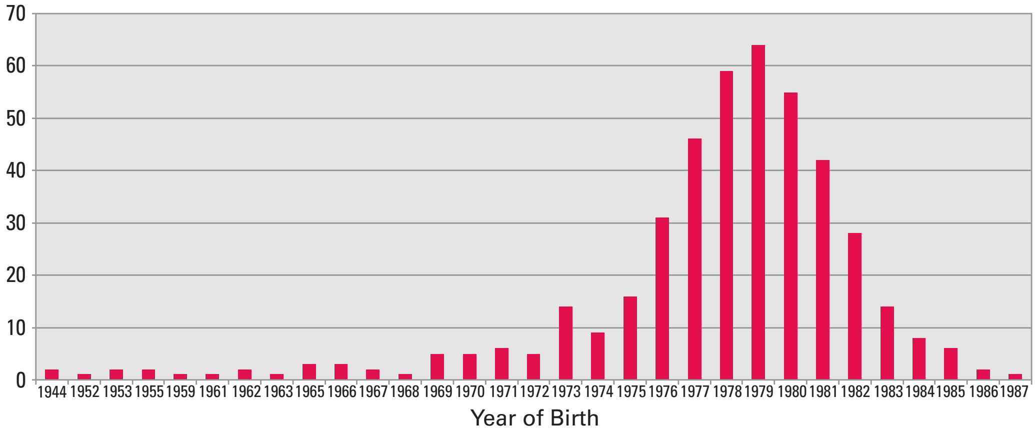

Figure 26. Year of birth of new PhDs

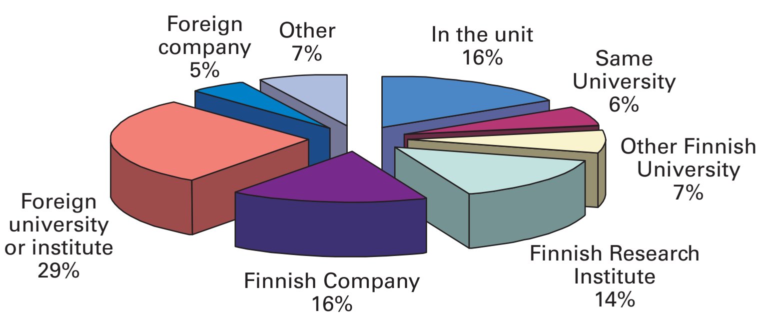

Figure 27. Present employment of new PhDs

of them at universities outside Finland. Finnish companies employed 16 per cent and foreign companies 5 per cent. The remaining 7 per cent includes, among other professions, civil servants, teachers and medical physicists in hospitals.

Of the 29 per cent remaining at Finnish universities, 16 per cent continued in the unit and 6 per cent at the same university, while 7 per cent moved to other universities. The 14 per cent proportion of Finnish research institutes is dominated by VTT and the FMI with equal proportions.

A8. Internationalisation

The units had research collaborations with more than 40 countries. The most popular country was the US with 134 collaborations and Germany had almost as many. The UK, Russia and France and Sweden followed next, before Japan. The proximity effect can be seen clearly (Figure 28): the other Scandinavian countries had about 30 collaborations while China had only 21, not to mention South Korea with only three, although the physics article production in this country is about half of that in Germany.

As concerns foreign industrial collaboration, the most popular partners were Germany (20 collaborations), the US (18), France (9), the UK (8) and Japan (6), the other countries being mostly from Europe. There were 32 thesis-related industrial collaborations, of which four with a German partner, one with an American partner and the remaining with Finnish partners, and 55 MSc theses with industrial collaboration, two with a Belgian partner, one with a German partner and the remaining with Finnish partners.

The units were asked to provide statistics on scientific visits made abroad by researchers at the doctoral level. The minimum duration for a visit was one month. Altogether 217 entries were reported by 28 units, or eight entries per unit, and the average duration of visit was eight months. There were 183 visiting researchers, so the majority have one entry. One person had five visits, six people had three visits and 19 people had two visits.

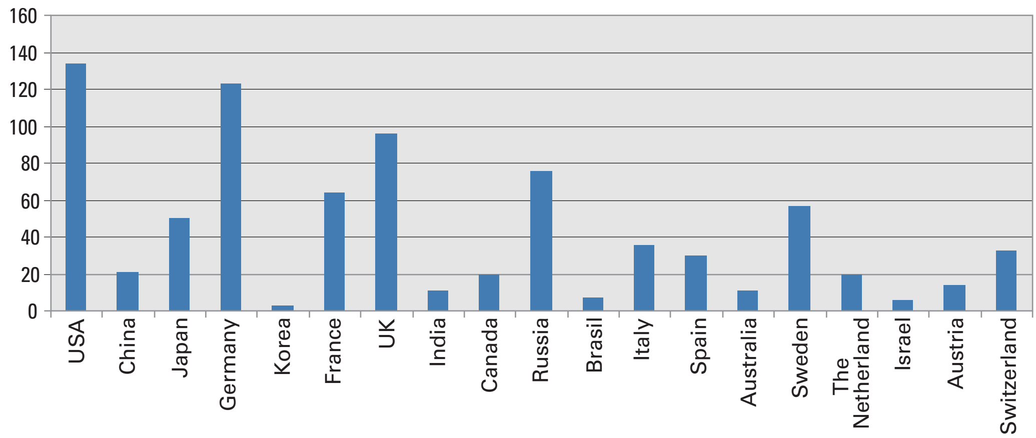

Figure 28. Numbers of research collaboration partners for 20 countries shown in the order of the total R&D expenditure of the country

The most popular visited country was the US, followed by Switzerland thanks to CERN. China was fifth after Germany and France and was followed by Sweden and the UK. A separate list of visits longer than one month by doctoral students was also asked. Altogether 175 entries were reported by 25 units and the average duration of visit was five months. Here, the order of popularity for visited countries is roughly the same, except that China had only four and the UK only two visits by doctoral students.

The statistics on visits from abroad to the unit were asked similarly for doctoral-level researchers and doctoral students. In the doctoral category, there were in all 182 visits, and Russia led the list with 27 visits, followed by the UK (18), Germany (16) and France (15). China, Sweden and Estonia had nine visits, Switzerland six visits and the US only five visits, the same number as Japan. Doctoral students from abroad made in all 253 visits to the units. Of these visits, 36 were made from the UK and 25 from China, while Germany, Russia and Sweden had 21 visits. The US had four visits and Japan three. The visits by doctoral-level researchers from and to the units are shown in Figure 29.

The units' internationalisation can be also quantified by the following figures reported by the units. There were 1,439 invited presentations in international meetings by 280 presenters, or about five presentations per presenter. The units listed 184 editing or board member tasks in scientific journals. These involved 90 different people and 60 different journals. The units also listed 725 representatives on international scientific boards and committees and 177 people, that is, on average four representation tasks per person.

The overall statistics on visits, summing up the doctoral and postgraduate level, for leading nations with respect to R&D expenditure are listed in Table 22 and Figure 30. The effects of proximity, collaboration traditions and the presence of highly ranked universities can be seen clearly. There is an imbalance for the US, as it accounts for almost 20 per cent of the visits of Finnish researchers, while only 3 per cent of visitors from abroad come from

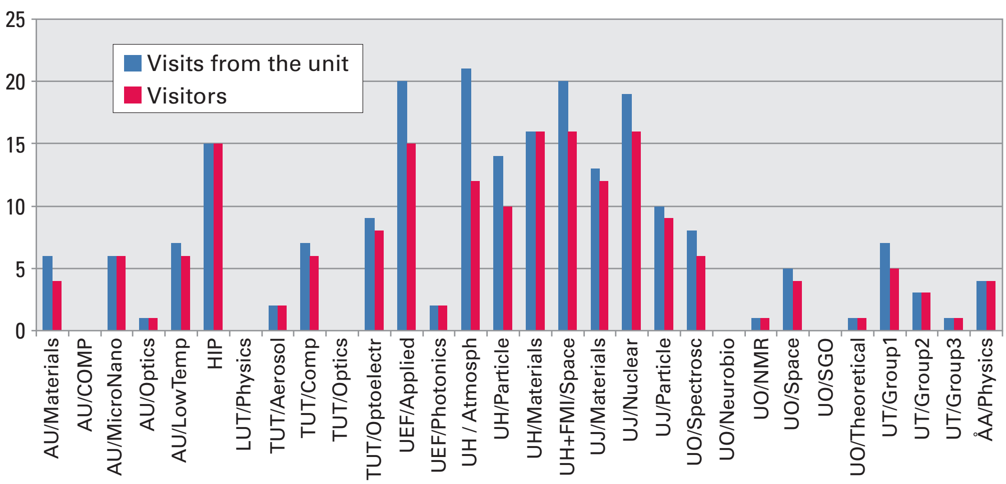

Figure 29. Visiting balance for doctoral-level researchers

the US. The similar situation for Switzerland can be understood because of CERN. Quite the opposite pattern is found for Russia and the UK, while the situation for Germany, France and Sweden is balanced. China has quite a high visiting activity in both directions and about three times higher than Japan with a similar research volume. Emerging research countries South Korea and India appear to be neglected by the Finnish physics community.

Table 22. Overall visiting statistics to leading R&D countries

	R&D 2011	From the unit		To the unit	
	Billion $	N	%	N	%
USA	405.3	66	19.3	9	2.9
China	153.7	20	5.8	34	10.8
Japan	144.1	7	2.0	8	2.5
Germany	69.5	48	14.0	37	11.8
South Korea	44.8	1	0.3	0	0.0
France	42.2	37	10.8	31	9.9
UK	38.4	11	3.2	54	17.2
India	36.1	1	0.3	7	2.2
Canada	24.3	12	3.5	3	1.0
Russia	23.1	10	2.9	48	15.3
Brazil	19.4	3	0.9	5	1.6
Italy	19	19	5.6	10	3.2
Taiwan	19	1	0.3	2	0.6
Spain	17.2	2	0.6	11	3.5
Australia	15.9	3	0.9	2	0.6
Sweden	11.9	26	7.6	30	9.6
Netherlands	10.8	11	3.2	9	2.9
Israel	9.4	0	0.0	3	1.0
Austria	8.3	4	1.2	2	0.6
Switzerland	7.5	60	17.5	9	2.9
All		342	100	314	100

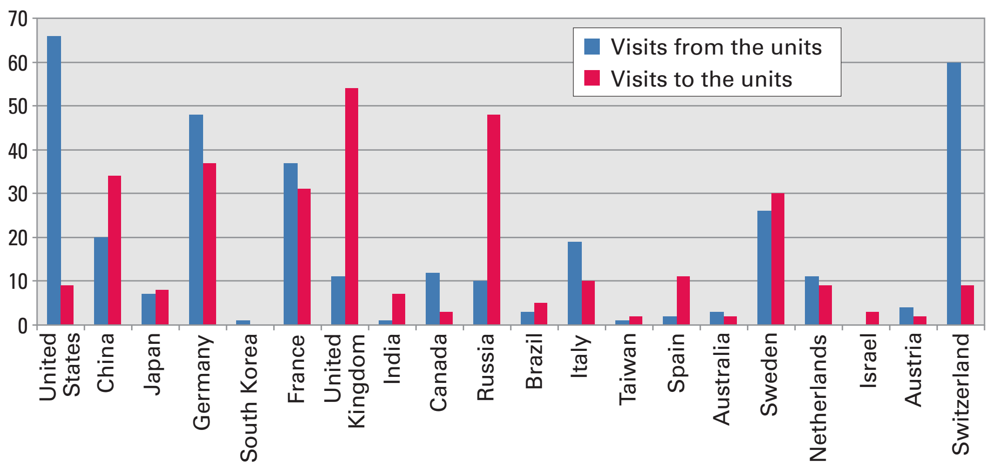

Figure 30. Visits from and to units for 20 leading countries with respect to R&D expenditure

Appendix B. Curricula vitae of panel members

Professor Christian Enss, Heidelberg University, Germany

Christian Enss is Full Professor of Experimental Physics at the Department of Physics and Astronomy of Heidelberg University. He was head of the department from 2008 to 2010 and is currently the Managing Director of the Kirchhoff-Institute for Physics. He obtained his PhD at Heidelberg University in 1991. After his postdoctoral stay as Feodor Lynen Fellow at Brown University, USA (1993), and his habilitation (1996), he worked as a professor at Bayreuth University, Konstanz University and Brown University before joining the faculty at Heidelberg University in 2004. He is an experimental physicist working on fundamental properties of condensed matter at low temperatures including amorphous materials, disordered crystals and spin glasses. Beyond condensed matter physics, he works in other areas of fundamental and applied physics, in particular on the development and application of cryogenic detectors for astronomy (X-ray spectroscopy), particle physics (neutrino mass determination) and atomic physics (Lamb-shift experiments). He has more than 110 publications in peer-reviewed journals and has written several reviews and textbooks. In the last decade, he has given more than 60 invited talks, more than 30 of which at international conferences. He has been a PI and coordinator of several national and international research projects and is a member of the editorial board of the *Journal of Low Temperature Physics*. He is founder and part-owner of Stella-Nova-Entertainment, a company devoted to science education and public outreach.

Professor Angela Bracco, University of Milan, Italy

Angela Bracco is Professor of Experimental Nuclear Physics at the Department of Physics of the University of Milan. She joined the University of Milan as an undergraduate student and obtained her Master's degree in 1979. For her PhD, obtained in 1983, she worked in the TRIUMF laboratory in Canada. She was assistant and associate professor in Milan and was appointed a full professor in 2002. She has chaired the Nuclear Physics Board of the Italian Institute of Nuclear Physics for several years. She is presently the chair of NuPECC, an expert board of the European Science Foundation. She is presently associate editor of the scientific journal *Nuclear Physics A*. She is a member of several scientific committees such as the GSI laboratory (Germany) and the IN2P3 Conseil Scientifique of CNRS (France). Her research is in the area of nuclear structure investigated in particular with gamma spectroscopy experiments. She has contributed to developments for large-volume scintillator detectors and to the study of collective nuclear properties also for nuclei at finite temperature. She has approximately 200 refereed publications.

Professor Jörg Büchner, Max Planck Institute for Solar System Research, Germany

Professor Jörg Büchner leads the Theory and Simulation of Solar System Plasmas group at the Max Planck Institute for Solar System Research. He teaches solar, space and plasma physics at the University of Göttingen. He got his PhD in 1980 and received a first habilitation (Dr of Sciences) for university teaching in Berlin in 1990 and, after he moved to the Max Planck Institute in Lindau, also in 1999 at Göttingen. From 1980 to 1992, he was affiliated with the Heinrich Hertz Institute for Solar-Terrestrial Physics and with the Astrophysical Institute of the Academy of Sciences in Potsdam, and from 1992 to 1997 with the Max Planck Institute for Extraterrestrial Physics, Berlin. He moved his Theory and Simulation of Solar System Plasmas group to the Max Planck Institute for Aeronomy, which recently became the Max Planck Institute for Solar System Research. He was a guest professor at the UCLA (USA, 1990–91) and at Nagoya University (Japan, 1999), and, since 2011, at the University of Nanchang (China). He has authored hundreds of scientific publications, in particular highly cited papers such as on nonlinear processes and the role of chaos in astrophysical plasmas. He was and is involved as a PI and a co-investigator in a number of space-based projects such as Interball, Cluster and Solar Orbiter. Among other things, he is associated editor of *Advances in Space Research* and *Nonlinear Processes in Geophysics*, a member of the Swedish Space Research Advisory Committee and the Scientific Committee of the International Conferences of Space Plasma Simulation (ISSS) as well as Head of the Extraterrestrial Physics Committee of the German Physical Society.

Professor Franco Cacialli, University College London, UK

Franco Cacialli is Professor of Physics in the Department of Physics and Astronomy and the London Centre for Nanotechnology at UCL, where he leads a group working on organic semiconductors and related nanostructures. He obtained his PhD from the University of Pisa in 1994. After postdoctoral work at Cambridge, he has been a Royal Society University Research Fellow (1996–2004) at Cambridge and University College London (UCL), before becoming Professor of Physics (2005). His research focuses on organic semiconductor (OS) properties and device applications (www.cmmp.ucl.ac.uk/~fc/OS/). He has used scanning near-field optical microscopy (SNOM) and scanning thermal probes for both investigation and manufacturing of OS nanostructures. A Fellow of the Institute of Physics (FinstP), a former member of the Advisory Board of *Materials Today* and of the *Journal of Physics Condensed Matter*, and a current member of EPSRC's Peer Review College, he has (co-)authored more than 200 publications and six patents. He has also coordinated a Marie Curie Training Network dedicated to threaded molecular wires (THREADed Molecular wIres as supramoLecularly engineered muLtifunctional materials THREADMILL, www.threadmill.eu) and co-edited (with P. Samori, Strasbourg) the book Functional Supramolecular Architectures (Wiley 2010, http://eu.wiley.com/WileyCDA/WileyTitle/productCd-3527326111.html). He was elected to a Fellowship of the American Physical Society in 2009.

Professor Hans-Friedrich Graf, University of Cambridge, UK

Hans-Friedrich Graf is Professor for Environmental Systems Analysis at the Geography Department of the University of Cambridge (since 2003). Before this, he was Senior Scientist at the Max Planck Institute for Meteorology in Hamburg, Germany, from 1991, and, from 1974 to 1990, Scientific Assistant at the Institute for Meteorology and Geophysics, School of Physics of the Humboldt University of Berlin, Germany, where he got his

Diploma in Meteorology (1974), his PhD (1979) and habilitation (1989). His research has always been a mixture of modelling and data analysis, examining all time and space scales of climate variations, from cloud microphysics to global general circulation. Recently, he has concentrated on processes of relevance to climate change, during the last years more focused on physico-chemical aspects of climate change, particularly aerosols, stratospheric ozone and fundamental modes of general circulation. He is also involved in volcano and biomass burning plume modelling. A more recent field is the modelling and parameterisation of convective clouds for use in non-cloud resolving models, which allows for consideration of chemistry-aerosol-microphysics processes. He has more than 160 publications in peer-reviewed journals. He has been a PI and a coordinator in a large number of national and European research projects and is currently co-chair of a COST action on theoretical aspects of convection parameterisation.

Professor Ulf Karlsson, Royal Institute of Technology, Sweden

Ulf Karlsson is Full Professor in Materials Physics in the Royal Institute of Technology (KTH) since 1997 and Director of the KTH Materials Platform since 2010. He obtained his PhD in physics from Linköping University, Sweden, in 1984, after which he worked as a scientist in the IBM Research Center, USA, and as an associate professor of synchrotron radiation physics in the Lund University MAX-LAB, Sweden. He joined the faculty of KTH in 1991 and worked as university lecturer and associate professor in materials physics before entering his present position. His present research areas are surface structure and electron structure research with scanning tunnelling microscopy/spectroscopy and synchrotron radiation spectroscopy, time-resolved laser photoelectron spectroscopy and electron dynamics, and synthesis and characterisation of functional oxides. He is author or co-author in more than 200 scientific articles and another 200 conference contributions on synchrotron radiation research, thin film physics and surface physics, and he has received more than 50 personal invitations to conferences. Among other memberships and responsibilities, he is chair of the Röntgen-Ångström collaboration with Germany, and is or has been a member of several national or European boards and evaluation groups relating especially to large-scale materials research infrastructures. He belongs to the editorial board of *Surface Review and Letters* and has acted as guest editor for *Applied Surface Science*, *Thin Solid Films* and *Physica*.

Professor Finn Ravndal, University of Oslo, Norway

Finn Ravndal is Professor of Theoretical Physics at the Department of Physics of the University of Oslo. He got his Dr.ing. degree in theoretical physics at the Technical University of Norway in 1968 and his PhD at Caltech, Pasadena in 1971. At that time, his research was concentrated on quark and parton models in collaboration with R.P. Feynman. After three more years in a postdoctoral position, he went to Nordita in Copenhagen in 1974 where he worked as a Senior Research Fellow. In 1976, he was appointed Full Professor of Theoretical Physics at the University of Oslo. There, he worked to build new courses in general relativity, elementary particle physics and modern quantum field theory. When high-temperature superconductivity was discovered in 1987, he initiated a research effort into the physics of particles with fractional statistics in two dimensions that had been discovered in Oslo several years earlier and had the potential to provide a mechanism for this new phenomenon in such layered materials. During this time, he was for many years a member of the Board for Nordita. As a consequence of this activity within condensed matter physics, much of his research interest turned later to finite-temperature field theory and associated phase transitions. In this connection, it was realised that the method of effective field theories provides a very efficient approach to obtaining high-precision results at low energies. After a year as a guest professor at the University of Washington in Seattle (1998–1999), this approach resulted in a very successful theory for few-nucleon interaction at low energies where the Coulomb interaction dominates. In particular, the most precise results for proton-proton fusion rate were obtained in this connection. His research in the last ten years has addressed questions within cosmological physics. In particular, specific models for dark energy based on the Casimir effect in extra dimension have been developed and tested against recent CMB satellite data. During this period, he was for three years a NorFa Visiting Professor at the University of Helsinki. He has approximately 100 refereed publications.

Professor Clare Yu, University of California, Irvine, USA

Clare Yu is a Full Professor in the Department of Physics and Astronomy at the University of California, Irvine. She received her AB (1979) and PhD (1984) degrees in physics from Princeton University. As a student, she worked at AT&T Bell Laboratories. She was a postdoctoral research associate at the University of Illinois, Urbana-Champaign, and a postdoctoral fellow at Los Alamos National Laboratory, before joining the faculty at the University of California, Irvine in 1989. She was an Alfred P. Sloan Fellow and is a Fellow of the American Physical Society. She is a theoretical physicist working in condensed matter and biological physics. She has worked on a wide variety of topics including disordered materials, phase transitions, noise, strongly correlated electron systems, intracellular transport, developmental biology and cancer. She has published 65 papers in her fields of interest. She is a member of the Aspen Center for Physics and the University of California Irvine Chao Family Comprehensive Cancer Center. She has served on the executive committee of the American Physical Society (APS) Division of Condensed Matter Physics, on the APS Division of Condensed Matter Physics nominating committee, on the APS Division of Biological Physics nominating committee, and on the University of California Academic Council Special Committee on (National) Lab Issues.

Appendix C. Terms of reference for the panel

Objectives of the evaluation

The evaluation concerns physics research in Finland, covering the period 2007–2011. The main objective is to evaluate the scientific level of research in international comparison. The evaluation report should contain a critical assessment of the quality and relevance of physics research in Finland and provide recommendations for the future development of the research. Specifically, the panel is asked to:

1. look at the research quality from three different viewpoints: the field as a whole, the different subfields and the research unit level (the evaluation will not assess individual persons but the unit as a whole)
2. assess the topicality and comprehensiveness of the distribution of physics subfields at Finnish universities
3. assess the sufficiency of available resources and their distribution across subfields
4. evaluate the adequacy of present or planned research infrastructures on local, nationwide, and international level
5. consider the following issues:
   - research networks, collaboration and mobility (national, international and multidisciplinary)
   - education and research career policies
   - impact on science and on society in general
   - any other issue the panel considers important

The evaluation includes 30 research units at nine universities and one research institute. The evaluation is based on the evaluation forms filled by the units and on the interviews by the evaluation panel.

Evaluation report and confidentiality

The results of the evaluation are collected to a report published by the Academy of Finland. The panellists will divide the work of writing the report among themselves. The main responsibility for collecting and compiling text from the panellists rests with the chair of the evaluation panel, who will be assisted by the coordinator of the evaluation. The Academy will provide editorial assistance for writing the report. The report will contain statements describing the research from three viewpoints as described above. The report will also contain recommendations of the panel.

Panel members will be provided certain detailed information intended for evaluation purposes only. The members are asked to keep such information, knowledge, documents or other matters confidential. The extent to which detailed data on the units can be used in the final report must be agreed between the panel, the Academy of Finland and the coordinator. The panel members are also asked to keep the evaluation report confidential before the publication date. Any possible conflicts of interest are also determined and handled based on discussions between the panellists, the Academy of Finland and the coordinator.

Appendix D. Evaluation form

The evaluation form consists of two parts:

Part I. Resources and research output of the unit
Part II. The unit's self-assessment

Part I: Selected parts of the information provided by the unit will be published in the evaluation report. Part II: The information provided by the unit will be used for evaluation purposes only and will not be published. No data concerning individual researchers will be published; the evaluation will not assess persons but the unit as a whole.

PART I. Resources and research output

1. GENERAL INFORMATION

A. Contact information

University
Unit in the evaluation
Address
Phone
Internet website
Contact person for the evaluation
Phone
Email
Faculty or equivalent higher level of organisation
Head of the faculty or equivalent
Phone
Email

B. The unit's research profile within the field of evaluation

Estimate the following physics subfield percentages respective to all your research (sum = 100%). For classification of research fields, please refer to the Academy research field classification (see annex).

Table 1.1

Research	%
Atomic and molecular physics	
Biological and soft-matter physics	
Condensed matter physics	
Fluid and plasma physics	
Particle and nuclear physics	
Optics, acoustics	
Other research within physical sciences, belonging to the field of evaluation (specify the subfield; you may add lines)	
Other research not within physical sciences (specify the subfield; you may add lines)	

2. RESOURCES

A1. Personnel

Include personnel funded through the unit's host organisation, or through some other funding source. Include only those doctoral students that have carried out their work in the unit. Visiting research staff is not included here but in section A2 below (Tables 2.4 and 2.5).

Full-time equivalents (FTE) for the evaluation period equals average person-years: (i.e. total/(12*5)).

Table 2.1

	Person months						
	2007	2008	2009	2010	2011	**Total 2007–11**	**FTEs for the period**
Doctoral level							
Professors							
Other senior researchers							
Postdoctoral researchers							
Total doctoral level							
Master's level							
Doctoral students							
Other academic staff holding MSc degree							
Total Master's level							
Total active research staff (sum of doctoral and Master's level)							
Assisting level							
Research assistants and graduate students							
Administrative personnel							
Technical personnel							
Total assisting, admin. and technical							
All staff							

List the *professors, other senior researchers and postdoctoral researchers* for the evaluation period

Table 2.2

Name	Sex	Year of birth	Title	PhD degree awarding organisation	Year of awarding	Period of employment in the unit

A2. Visiting researchers

Include visiting researchers coming from abroad or Finland, when the funding for the visit has been arranged through the activity of your unit (e.g. Academy of Finland, Tekes, EU funding).

Table 2.4

	Person months						
	2007	2008	2009	2010	2011	**Total**	**FTEs for the period**
Visiting professors							
Visiting senior researchers							
Visiting postdoctoral researchers							
Visiting doctoral students							
All visiting researchers							

Included in the table above, list the *visiting professors, senior researchers and postdoctoral researchers* here. Visiting doctoral students will be listed in section 4E, Visits to the Unit, Table 4.7.

Table 2.5

Name	**Sex**	**Title**	**Degree**	**Period of visit**	**Home organisation and the subunit**	**Country**	**Source of funding**

B. Funding

List the funding of the unit over the evaluation period.

Table 2.6

		2007	2008	2009	2010	2011	**Total**
Core funding	**Budget funding**						
	Other						
External funding	**Academy of Finland**						
	Doctoral programmes (Min.Edu.)						
	Tekes						
	Other public sources						
	Industry						
	Private foundations						
	EU						
	Other foreign organisations						
Total							

3. RESEARCH OUTPUT

A. Number of scientific publications and other outputs

This is based on the new classification by the Academy of Finland (2010).

Table 3.1

	2007	2008	2009	2010	2011
A Peer-reviewed scientific articles					
A1. Articles in refereed scientific journals					
A2. Other articles (review article; book section; conference proceedings)					
B Non-refereed scientific articles					
C Scientific books (monographs)					
D Publications intended for professional communities					
H Patents and invention disclosures					
H1. Granted patents					
H2. Invention disclosures					
I Audiovisual material, ICT software					
Other, specify					

B. Degrees

Table 3.2

	2007	2008	2009	2010	2011
Master's degrees					
Number of doctoral students					
Number of full-time doctoral students					
Completed doctoral degrees					

List of doctoral dissertations in 2007–2011.

Table 3.3

Name (family name, given name)	Year of birth	Gender	Title of dissertation	Year of starting postgraduate studies	Year of completing degree	Years worked in the unit during postgraduate studies	Present employment (job description, organisation)

4. NATIONAL AND INTERNATIONAL COLLABORATION

Throughout this section, do not use abbreviations for institutes and universities but spell them out. Target the collaboration and visits to the period of evaluation (2007–2011). More detailed content of the collaboration and important project consortia can be described in Part II: Collaboration.

A. Extent of collaboration

Give the percentages for co-authoring partners within your refereed journal publications over the evaluation period (co-author = co-author outside the unit).

Table 4.1

Percentage of refereed journal publications	2007	2008	2009	2010	2011
No co-author outside the unit					
Domestic co-author only					
Foreign co-author only					
Both domestic and foreign co-authors					

B. National collaboration

List your most important national collaborations. The collaborating unit may also be from the same university or research institute, or from industry.

The type of collaboration may be, for example, joint projects, personal collaboration, research mobility or networking.

The outputs may be, for example, refereed scientific publications, other publications, patents or other outputs, educational with MSc and PhD theses, facilities or instrumentation, prototypes or methodologies, or networks.

Table 4.2

Main organisation and collaborating subunit	Type of collaboration and field of science (see annex)	Output

C. International collaboration

List your most important international collaborations with the same criteria as in Section 4.B.

Table 4.3

Main organisation and collaborating subunit	Country	Type of collaboration and the field of science (see annex)	Output

D. Visits abroad from the unit

In the following, list only visits by *researchers on doctoral level* of Table 2.2. Include only such cases where the total duration of visits during the evaluation period was at least one month.

Table 4.4

Name	Destination organisation and visited subunit	Country	Total length of visits

In the following, list the visits abroad made by *doctoral students.* Include only such cases where the total duration of visits during the evaluation period was at least one month.

Table 4.5

Name	Destination organisation and visited subunit	Country	Total length of visits

E. Visits to the unit

Include *visiting professors, visiting senior researchers and visiting postdoctoral researchers* when the funding has not been organised through the activities of your unit. Include only such cases where the total duration of visits during the evaluation period was at least one month. Do not include visiting researchers from section 2. A2.

Table 4.6

Name and title of visitor	Home organisation and visitor's subunit	Country	Field of science (see annex)	Total length of visits

In the following table, list the visits to the unit made by *doctoral students* from other universities irrespective of the funding source. Include only such cases where the total duration of visits during the evaluation period was at least one month.

Table 4.7

Name	Home organisation and visitor's subunit	Country	Total length of visits

F. Industrial collaboration

In the following table, list only such collaborations where *researchers on doctoral level* listed in Table 2.2 have participated.

Table 4.8

Collaborating organisation and subunit	Country	Type of collaboration	Output of collaboration

In the following, list cases where industrial collaboration has constituted an essential part of completed doctoral studies.

Table 4.9

Collaborating organisation and subunit	Country	Title of dissertation (from Table 3.3)

In the following, list MSc theses done in industry.

Table 4.10

Collaborating organisation and subunit	Country	Title of MSc thesis

5. Research infrastructures

A. Research infrastructures (RI) exploited by the unit

Indicate whether the RI is local (designed only for the needs of your unit or institution), national (designed for a larger user community than just one institution) or international (designed to serve international users).

Name/type of RI	Local/national/international	Administrating organisation

B. Research infrastructures offered to other users by the unit

Indicate whether the RI is local (designed only for your own needs), national (designed for a larger national user community than just your institution) or international (designed to serve users also outside Finland).

Name/type of RI	Local/national/international	Administrating organisation

6. OTHER SCIENTIFIC AND SOCIETAL ACTIVITIES

Throughout this section, include only *researchers on doctoral level* of Table 2.2. Mark the activities to the period of evaluation (2007–2011). Do not use acronyms of journals, conferences, institutions etc., but spell them out.

Invited presentations in scientific conferences

Table 6.1

Name	Title of presentation	Name of conference	Year

Memberships in editorial boards of scientific journals

Table 6.2

Name	Journal	Period

Representatives in international scientific boards, committees and equivalent

Table 6.3

Name	Board etc. and task	Period

Prizes awarded to researchers, honours, scientific positions of trust and equivalent

Table 6.4

Name	Prize, position etc.

Representatives in committees and in scientific advisory boards, companies, or other similar tasks primarily not of academic nature

Table 6.5

Name	Company, board etc. and task	Period

PART II. THE UNIT'S SELF-ASSESSMENT

A. Describe the unit's research and strategy (max. 2 pages)

B. SWOT – evaluation of the unit's scientific strengths, weaknesses, opportunities and threats (expertise, funding, facilities and organisation; max. 2 pages)

C. Assess the research infrastructure available (max. 1 page)

What is the status of the present RIs you use? Do you intend to utilise other, already existing RIs?

Do you have plans to use future RIs that are planned or under construction? Please discuss local, national and international RIs, as applicable.

D. Most important publications

Include a numbered list of the most important publications of the unit in the field of physics during 2007–2011. Please include 5–8 publications for each professor together with his/her research group.

List the publications in order of importance (for each professor). Give a short justification for your assessment of importance (original findings and new insights) after each paper.

Send the unit's ten most important publications to fysiikka@aka.fi as a zipped file and/or paper copies.

E. Evaluate the unit in relation to its leading scientific competitors (max. 1 page)

F. Collaboration (max. 2 pages)

Describe most important collaborative projects and consortia (max. 1 page).

Describe the most important outcomes of the collaboration (max. 1 page).

G. Societal impact (max. 1 page)

Describe the societal impact of the unit's activities.

Describe the unit's public visibility.

H. Administrative and educational load (max page)

Describe the nature of administrative and educational duties.

I. Funding

Assess, from your point of view, the funding from the following sources:

Funding by the Academy of Finland. Please emphasise the Academy's role in promoting the scientific, educational and societal impact of research (max. 1/2 page).

List the researchers who have held an Academy position (Academy Professor, Academy Research Fellow, Postdoctoral Researcher, FiDiPro).

Name	Position	Period

Funding awarded by **other funding organisations** in promoting the scientific, educational and societal impacts of research. Assess especially Tekes and EU funding, including ERC grants (max. 1 page).

Funding obtained from industry in promoting the scientific, educational and societal impacts of research (max. 1 page).

J. Future prospects

Assess the future prospects of your unit and your research field on both a global and a Finnish scale. How do you expect the situation to look like after 5–10 years?

This report presents an international evaluation of physics research in Finland. The evaluation includes 30 physics units and covers the period 2007–2011.

The aim of the evaluation was to assess the quality of physics research and its subfields as compared to international standards. The evaluation considers the field of physics in general, covering the issues of quality and scope, funding, recruitment, PhD training, societal relevance and internationalisation. It also presents evaluations of each unit.

The report includes the panel's observations and recommendations for the future.

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