

QANU Research Review Physics

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FOREWORD

This report follows the Standard Evaluation Protocol 2009-2015 (SEP) for Research Assessment in the Netherlands that was developed by VSNU, KNAW and NWO. The purpose of this report is to present a reliable picture of the research activities submitted for this review and to give feedback on the research management and quality assurance.

The review Committee was supported by QANU (Quality Assurance Netherlands Universities). QANU aims to ensure compliance with the SEP in all aspects and to produce independent assessment reports with peer review committees of international experts in the academic fields involved.

QANU wishes to thank the chairpersons and members of the review Committee for their participation in this assessment and for the dedication with which they carried out this task.

We also thank the staff of the units under review for their carefully prepared documentation and for their co-operation during the assessment.

Quality Assurance Netherlands Universities

Mr. Chris J. Peels
Director

Dr. Jan G.F. Veldhuis
Chairman of the Board

PREFACE

The present evaluation report is the result of a constructive interaction between the staff at the universities and the committee members. The evaluation documents and the site visits enabled the committee to perform its task efficiently. The committee thanks the institutes and programme leaders for their self-evaluations and for very interesting site visits. I thank all involved for their professional attitude and perseverance during the review process. The chairs of the three subcommittees (Hilbert von Löhneysen, Friedrich Wagner and Sanjoy Banerjee) and the committee members all showed great dedication and flexibility. Their expertise is at the core of this review.

Three subcommittees covered all institutes and programmes with parallel site visits within just one week. Clearly this was a compromise and an experiment. It worked out well, thanks to the concentrated efforts during that week, and thanks to the careful preparations and the time that was spent after the visits for writing the drafts and answering the faculty comments. The essential support by QANU (Roel Bennink c.s.) throughout the evaluation is greatly appreciated.

I trust that the efforts of all involved in this review will contribute to a clear and convincing image of the quality of physics research in the Netherlands and to its further successes in the interest of society.

J. Friso van der Veen
Chairman of the Review Committee

1. THE REVIEW COMMITTEE AND REVIEW PROCEDURES

Scope of the assessment

The Committee was asked to perform an assessment of the research in Physics at the University of Groningen (RUG), University of Twente (UT), Radboud University Nijmegen (RU), Eindhoven University of Technology (TUE), University of Amsterdam (UvA), VU University Amsterdam (VU), Utrecht University (UU), Delft University of Technology (TUD), and Leiden University (LEI). This assessment covers the research in the period 2001 - 2009.

In accordance with the Standard Evaluation Protocol 2009-2015 for Research Assessment in the Netherlands (SEP), the Committee's tasks were to assess the quality of the institutes and the research programmes on the basis of the information provided by the institutes and through interviews with the management and the research leaders, and to advise how this quality might be improved.

Composition of the Committee

The composition of the Committee was as follows:

1. Subcommittee for Groningen, Twente, Nijmegen (RUG, UT, RU)

- Hilbert von Löhneysen, Universität Karlsruhe (TH), subcommittee chair
- Masao Doi, The University of Tokyo
- Monika Ritsch-Marte, Medical University of Innsbruck
- Friso van der Veen, ETH Zurich
- Albrecht Wagner, University of Hamburg

2. Subcommittee for Eindhoven, Amsterdam (TUE, UvA, VU)

- Friedrich Wagner, Max-Planck-Institute of Plasma Physics, subcommittee chair
- Siegfried Bethke, Max Planck Institut für Physik
- Phil Bucksbaum, Stanford University
- Paul Chaikin, New York University
- Jean-Louis Martin, École Polytechnique
- Martin Stutzmann, TU München

3. Subcommittee for Utrecht, Delft, Leiden (UU, TUD, LEI)

- Sanjoy Banerjee, City University of New York (CUNY), subcommittee chair
- John Brady, California Institute of Technology
- Jonathan Richard Ellis, King's College London
- Rob Hartman, ASML, Eindhoven.
- Jürgen Kurths, Humboldt University of Berlin
- Gerhard Rempe, Technical University of Munich
- Erio Tosatti, International School for Advanced Studies (SISSA), Trieste.

Prof. Friso van der Veen acted as chairman of the Committee.

A short profile of the members of the Committee is provided in Appendix 2.

Roel Bennink of the Bureau of QANU (Quality Assurance Netherlands Universities) was appointed secretary to the Committee, with Barbara van Balen and Trees Graas as co-secretaries.

Independence

All members of the Committee signed a statement of independence to safeguard that they would assess the quality of the Institutes and research programmes in an unbiased and independent way. Any existing personal or professional relationships between Committee members and programmes under review were reported and discussed in the committee meeting. The Committee concluded that there were no unacceptable relations or dependencies and that there was no specific risk in terms of bias or undue influence.

Data provided to the Committee

The Committee has received detailed documentation consisting of the following parts:

1. Self-evaluation reports of the units under review, including all the information required by the Standard Evaluation Protocol (SEP), with appendices;
2. Copies of three key publications per research programme;
3. Results of the bibliometric study carried out by the Centre for Science and Technology Studies (CWTS).

Procedures followed by the Committee

The Committee proceeded according to the Standard Evaluation Protocol (SEP). Prior to the Committee meeting, each programme was assigned to two reviewers, who independently formulated a preliminary assessment. The final assessments are based on the documentation provided by the Institutes, the key publications and the interviews with the management and with the leaders of the programmes. The interviews took place on 28-30 June 2011 on location at the Institutes, in parallel with three subcommittees. On Monday 27 June, the Committee was briefed by QANU about research assessment according to SEP, and the Committee discussed the preliminary assessments. The Committee also agreed upon procedural matters and aspects of the assessment.

Also on Monday 27 June, the Institutes presented themselves in a series of presentations, followed by questions from the Committee. On Friday 1 July, after the site visits, the Committee convened in Utrecht to calibrate the scores of the subcommittees and to agree on the main recommendations. In the afternoon a special meeting with the rector magnificus of Utrecht University was organised, to discuss the background of the very recently announced plans for refocusing.

The texts for the committee report were finalised through email exchanges. The final version was presented to the faculties for factual corrections and comments. The final report was presented to the boards of the participating universities and was printed after their formal acceptance of the report.

The Committee used the rating system of the Standard Evaluation Protocol (SEP). The meaning of the scores is described in Appendix 1.

2. GENERAL REMARKS

Introduction

Physics in the Netherlands is in excellent shape. Bibliometric studies by CWTS show that Physics at Dutch universities is a factor 1.8 above world average as regards both the number of citations per paper and the number of highly cited papers. Physics shares these high scores with Chemistry, and the Netherlands ranks in both disciplines number two among nations worldwide. The Committee saw the international visibility and high quality of Physics fully confirmed in their evaluation. Physics in the Netherlands builds on a long and rich tradition. Physics groups continue to attract young talented scientists and profit from an excellent technical infrastructure.

The evaluation encompassed all Physics programmes in the Netherlands, thus enabling comparison between institutes and programmes at different universities. The Committee found governance practices at the institutes generally well-developed, providing a stimulating environment for scientists. Personal research awards such as the NWO funded VENI, VIDI and VIDI fellowships and ERC grants play a crucial role here. Programmes such as the Rosalind Franklin programme in RUG enable qualified women to start a career in science and are perfect instruments to promote gender equality.

A number of the institutes evaluated are of a multidisciplinary character. The Committee, having been asked to evaluate only the Physics programmes in such institutes, occasionally felt that more justice to the multidisciplinary approach would be done if the scope of evaluation in such cases would be widened.

The Committee was informed about the Sector Plan Chemistry and Physics and its beneficial role in concentrating activities, avoiding duplication of efforts and fostering collaborations between different groups. Concentration of efforts and sharing of resources are since long common practice in Particle Physics, where in the Netherlands Nikhef plays a pivotal role. The Committee noticed already existing coordination in teaching and research between LEI and TUD, UvA and VU, and RUG, UT and RU. The Sector Plan rewards this type of coordination through a number of extra positions in strategic areas.

Overview of the evaluation results

Quality

The average score for quality of the programmes is 4.6. No university has less than 4 as the average score for the quality of the programmes. Twenty-two programmes were rated excellent for quality (5), five are very good to excellent (4.5) and thirteen programmes were rated very good (4). Our findings are by and large consistent with the outcome of the citation analysis by CWTS. Where deviations occur, the Committee has taken other factors into account such as applied research or instrumentation projects whose results are generally published in a field journal or patented instead of being published in a high-impact journal. For these factors to be properly taken into consideration, the Committee found the site-visits to be of essential importance.

Productivity

Publications statistics were presented for each programme, normalized to the number of staff. The normalization does justice to the groups that publish less because of smaller size. The Committee has noted a trend toward forming smaller research groups; they are generally started by independent young scientists on tenure-track positions. 'Focus and mass' can still be achieved by having these groups work together and share resources. This governance structure proves to

be effective in scientific output and quality assurance.

Relevance

Societal relevance in this review covers three types of activities (in accordance with SEP):

- productive interaction between researchers and stakeholders (professionals, politicians, interest groups, patient organisations, environmentalists, etc.)
- valorisation (or value creation, especially in the economic sense) via spin-offs, patents, processes, etc.
- outreach activities aimed at the general public (media appearances, books, campaigns, open days, public lectures, etc.)

The SEP criteria for Societal relevance are broadly defined, including not only economic but also social and cultural aspects. The Committee has noticed that the notion of societal relevance of research at universities is still surrounded by some controversy and confusion. We believe that the self-assessment reports could have contained more detailed information on results that were evidently beneficial to industry and have led to new or improved products and processes.

The issue of relevance eventually revolves around the question: ‘what is the role of Physics in society?’ Although there is probably no unique answer to this question, it is a fact that much of the technology surrounding us has its roots in fundamental Physics and Chemistry discoveries. The preferred role of physicists therefore is not only to advance the discipline itself and to train highly qualified scientists, but also to directly contribute to technological innovations. The Committee has seen great examples of ‘valorisation’, but some Committee members wonder how strategic choices on applied Physics programmes in the Netherlands are made, how the roles of national funding agencies and applied research institutes (FOM, STW, Agentschap NL, TNO) are coordinated and what is expected from the universities.

Viability

The strength and the potential of the programmes for the future gave on average for the forty programmes that were assessed a very good score of 4.6. A threatening factor is the generally decreasing baseline (first-party) funding during the evaluation period, which most groups have so far compensated by obtaining increased funding from other sources (FOM, Agentschap NL). Given the funding uncertainties at present, the Committee has not taken this potential threat into account in the programme scores for viability.

The Committee is concerned about the viability of large facilities in the Netherlands (e.g. KVI, HMFL). The potential of these facilities and of its well-trained operational staff is not fully exploited. Clear guidance and perspectives should be given by NWO and FOM as regards investments in new facilities and their sustained operation. For lack of a national centre providing a permanent technical infrastructure, universities take up the role of host, but their long-term commitments are unclear.

3A. INSTITUTE LEVEL - University of Groningen

University: University of Groningen
Faculty: Faculty of Mathematics and Natural Sciences

1. The institutes

Physics research at the University of Groningen is carried out in two organisational entities, the Faculty of Mathematics and Natural Science (FMNS) and the Kernfysisch Versneller Instituut (KVI).

FMNS

The Faculty of Mathematics and Natural Science (FMNS) is a broad faculty that performs fundamental research in a diverse spectrum of disciplines including physics, astronomy, mathematics, chemistry, industrial engineering and management, computer sciences, artificial intelligence, biology and pharmacy. Research is executed in 12 (inter)disciplinary research institutes each headed by a scientific director. Three of these institutes comprise physics research:

- Zernike Institute for Advanced Materials
- Centre for Theoretical Physics (CTN)
- Energy and Sustainability Research Institute Groningen (ESRIG).

RUG has not asked for an assessment of the institutes Zernike, CTN and ESRIG, only of KVI.

KVI

The Kernfysisch Versneller Instituut (KVI) is an interfaculty institute at the RUG; it reports directly to the Executive Board of RUG. It is the only accelerator centre in the Netherlands. The research conducted in the KVI is focussed on the fundamental forces and symmetries in nature and applications of the developed methods and instrumentation. The research area comprises 6 research lines:

1. Fundamental Interactions and Symmetries (TRI μ P¹)
2. Theoretical Subatomic Physics (TSP)
3. Atomic and Molecular Physics (AMO)
4. Accelerator Physics (ACC)
5. Hadrons- and Nuclear Physics (HNP)
6. Astroparticle Physics (APP)

KVI participates in the teaching of FMNS and since 2010 fully participates in the scientific education of graduate students in the Groningen Graduate School of Science. KVI, the Centre for Theoretical Physics (CTN) and the Kapteyn Astronomical Institute have recently initiated the master's programme *Quantum Universe* to promote teaching as well as research in the interdisciplinary field between physics and astronomy.

Assessment/remarks

KVI represents a major research asset with its various technical skills and support staff, required to build and operate a major research infrastructure.

¹ TRI μ P: Trapped Radio-active Isotopes microlaboratories for fundamental Physics

KVI

The central facility of KVI is AGOR, a superconducting K=600 MeV cyclotron for the acceleration of light and heavy ions. In view of the fact that AGOR operation will stop being funded in 2014, KVI, together with scientists from the Zernike Institute, has developed the plan to build and operate a Free Electron Laser in the soft x-ray domain.

Together with the Laser Centre at the Vrije Universiteit Amsterdam, the KVI recently acquired a FOM-subsidy of 2.9 M€ for a precision laser measurement programme, which enables the continuation of a scientifically significant part (high precision ion and molecule spectroscopy) of the TRIµP research into 2017. In addition, in the period 2004-2009 KVI scientists have obtained 28 research grants from NWO, EU projects and with collaborations with the European Space Agency (ESA) and its industrial partners. Altogether these activities amount to an additional 6.5 M€ in the period 2004-2009. FOM projects supply annually about an additional 1M€.

KVI was part of the EURONS nuclear structure Integrating Infrastructure Initiative (2005-2008) in the EU-FP6 programme, with a share of 149 k€ for science projects and 700 k€ for transnational access to AGOR as a large scale facility. In the new FP7 EU framework programme KVI provides the co-ordinator of the follow-up consortium ENSAR (2010-2014). Here 125 k€ are provided for KVI projects and 345 k€ are available for transnational access to AGOR. The atomic physics facility ZERNIKE LEIF (Low Energy Ion Facility) at KVI is a recognized large scale facility and operates in the framework of the ITS LEIF consortium (2006-2010) within the EU-FP6 yielding 440 k€ of income for transnational access.

The main KVI funding (2009) originates from the university (49%), the Dutch Foundation FOM (27%), the Dutch Science Foundation NWO (10%) and the German Helmholtz Zentrum für Schwerionenforschung GSI (10%). The remaining funding is provided through contracts including the European Union and industrial partners.

The self-evaluation report mentions that the KVI has insufficient structural base funding to maintain all research topics and optimal base resources; KVI therefore strongly depends on third party funding. It is KVI policy to obtain half of its funding from other sources than the RUG.

Assessment/remarks

The tenure-track system as well as the Rosalind Franklin Programme are clear assets that have proven to be effective in attracting talented staff and keeping them.

The Committee notes that KVI has been successful in acquiring funds from several sources, but the lack of a political strategy for funding and operating large infrastructural research facilities in the Netherlands, is a threat to the stability of KVI.

4. Productivity

The results of the CWTS-analysis show that the Groningen programmes under review have produced 1271 articles in Web of Science journals in the 6-year period 2004-2009. These articles were cited 18150 times, not counting self-citations. The mean citation score is 17.22 for Advanced Materials, 9.74 for Theoretical High-Energy Physics, 25.98 for Isotope Research, and 6.77 for Atomic and Subatomic Physics.

The highest number of papers among the 10% most frequently cited papers is 155 for the group Advanced Materials. The number of articles per full-time equivalent of academic staff ranges from 1.4 for Advanced Materials to 3.1 for Isotope Research.

Assessment/remarks

The research programmes under review have received very high scores for productivity.

5. Societal Relevance

The applied research of KVI with a spearhead in medical physics is relevant to important topics such as particle therapy of cancer and medical imaging. The research aims at state-of-the-art cancer treatment with particle beams and a better understanding of the underlying fundamental (physical and biological) processes in the interaction of radiation with biological matter. In collaboration with international physical, biological and medical scientists, KVI aims to come to a patient treatment facility in the north of the Netherlands.

The self-evaluation report mentions that the ongoing research on the physics and biology of particle therapy in relation to cancer therapy using proton and carbon beams could recently be expanded significantly and important basic measurements of high relevance to cancer treatment can be performed at AGOR. In addition, cyclotron beams are successfully employed for testing of spacecraft instrumentation.

The AGOR cyclotron facility will be used for research connected to cancer therapy until 2014, when the research will shift to the University Medical Centre (UMCG). KVI and the UMCG plan to construct a new hospital-based cancer treatment and cyclotron facility within 5 years.

Assessment/remarks

The Committee notes that the international collaboration between physical, biological and medical scientists on cancer treatment has a high potential for societal relevance.

6. Strategy for the future

The FMNS and KVI endorse the Sector Plan Physics and Chemistry to further profile teaching and research in six key areas (with the relevant institutes between brackets):

1. Theoretical and Subatomic Physics (CTN, KVI)
2. Functional Materials (Zernike Institute)
3. Molecular Chemistry (Stratingh Institute, Research Institute of Technology and Management ITM, Groningen Biomolecular Sciences and Biotechnology Institute GBB)
4. Energy and Sustainability (ESRIG, ITM, Stratingh Institute, GBB)
5. Biomedical Science and Engineering (Zernike Institute, KVI)
6. Biomolecular Chemistry and Engineering (GBB, Stratingh Institute)

The aim of FMNS is to enhance these activities by starting five new research groups of which three are intimately associated to physics, namely: a) Devices of Complex Materials, b) Cell Biophysics, and c) Modelling of Atmospheric Compositions. These research groups complement current research, increase focus and mass and address challenging research questions of high societal relevance.

Concerning education, FMNS will focus on three profiles: Science and Technology, Energy and Sustainability, and Life and Health. By adding research expertise to these profiles the Sector Plan will increase the appeal of the BSc en MSc degree programmes and the PhD track. This focus on specific profiles is in line with the university's policy to strengthen its key areas as well as with the so-called Groningen Agreement.

With the envisioned actions in teaching in the aforementioned profiles, the FMNS aims to increase the influx to at least 100 students for Physics and Applied Physics, with at least 30%

female students in each degree programme, and to achieve a BSc pass rate of 70%.

KVI

As the major and central goal for its future, KVI promotes ZFEL (Zernike Free Electron Laser), a compact soft X-ray free electron laser facility. This initiative is driven by scientists from KVI and the Zernike Institute for Advanced Materials and supported by a number of universities, companies and institutes in the Netherlands and abroad. It aims at a soft X-ray laser source at the KVI site, which exploits state-of-the-art electron source, linear accelerator and undulator technology to achieve a national soft röntgenlaser facility of international standing. It will be complementary to the X-FEL facility in Hamburg, which operates at shorter wavelength.

Assessment/remarks

The Committee believes that KVI and the Faculty are taking appropriate action towards a coherent strategy for the future. Realisation of the ambitions of KVI will depend on strategic decisions to be made by the agencies FOM and NWO, also in the framework of the Top Sectors.

7. PhD Training

Since 2009, the PhD training and supervision has been integrated in the Graduate School of Science (GSS), providing a competence development programme and training resource to all PhD students within the FMNS. The GSS has an independent status and is headed by a director, who is supported by a graduate school coordinator and an administrative office. The main responsibility of the GSS is to provide an optimal training environment for all PhD students in the faculty. All PhD students have a Training and Support Plan describing in detail what they can expect from their supervisors, their research institute and their faculty, and what in turn is expected from them.

In close collaboration with various local and national research schools the GSS organizes and coordinates a course programme, including transferable skills courses like Project Management, Scientific English, or Career Development. All PhD students receive an Individual Training Budget allowing them to participate in local courses, international summer schools, or conferences. By various means, PhD students are encouraged to “master their own PhD” and to play an active role in the research community. In particular, the GSS awards credits to PhD students who organize literature clubs, master classes, workshops, scientific debates, or all kinds of networking activities.

The GSS also developed a progress monitoring system. In addition to the regular meetings with their supervisors, all PhD students have annual progress meetings where the state and development of their research, their training, and their scientific competences is discussed, and where the students can provide feedback on the working environment and the quality of supervision. The GSS ensures that the progress meetings do actually take place on a regular basis and evaluates whether on the basis of the progress reports there is any need for extra measures or support.

KVI

Since 1994 the academic training of KVI PhD students is organized by the international research school FANTOM (Fundamental and Applied Nuclear and aTOMIC physics). FANTOM is a collaboration of research institutes from the universities of Groningen (NL), Münster (D), Gent (B), Leuven (B) and Orsay/Paris (F). It is foreseen that in the near future partners from the Vrije Universiteit Amsterdam, the Universität Heidelberg and ETH Zürich (PSI Villigen) will join. Within FANTOM KVI has the central role as founding and coordinating institute.

Since 2010 FANTOM participates in the RUG Graduate School of Science (GSS). KVI follows the GSS educational programme wherever it is compatible with the internationally agreed FANTOM programme. The educational programme of FANTOM amounts to 36 EC. The programme includes activities in the fields of transferrable skills, general research techniques, advanced scientific courses, and project-related activities. PhD students are obliged to attend at least four general FANTOM study weeks and to present their research at least once.

Almost all PhD students graduate within their fifth year. The average duration of PhD projects at KVI was lowered to 4.3 years. KVI aims to reduce this to below 4 years.

Assessment/remarks

The Committee acknowledges the important role of KVI in the international research school FANTOM. The participation of FANTOM in the RUG Graduate School of Science ensures a fruitful combination of local and international orientation.

3B. PROGRAMME LEVEL - University of Groningen

Programme RUG 1: **Advanced Materials**

Programme leaders: Prof. J. Knoester (2004-2009), Prof. T.T.M. Palstra (since 1-1-2010)

Research staff 2009: 91.2 fte

Assessments:	Quality:	5
	Productivity:	5
	Relevance:	5
	Viability:	5

The collaborative research programme of the physics part of the Zernike Institute for Advanced Materials focuses on two areas:

- *Complex Functional Materials*

A first long-term objective is to design and synthesize multifunctional materials with a broad spectrum of desired properties. One focus has been on correlated electron systems with relatively simple crystal structures where the strong interplay between spin, charge, dipolar, orbital, and lattice degrees of freedom leads to unconventional behaviour, new functionalities and strongly enhanced response to applied fields. Another focus has been on macromolecular systems providing functionality and/or self-organization.

The specific aims of this programme are designing, synthesizing, understanding, and controlling materials that are patterned on the nanoscale and tuning their properties to achieve desired interface functionality.

- *Electromagnetic Functionality*

A second long-term objective is to understand, apply, and exploit the excited-state dynamics, energy, and charge transport in organic materials (and devices) and to relate these properties to interactions and processes at the molecular level. This microscopic understanding is of interest in its own right and is essential for new technological applications, such as transistors, light emitting diodes, organic solar cells, and molecular electronics. Furthermore, understanding and being able to control these processes will form a foundation to start integrating organic materials with biological systems.

The specific aims of this programme are 1) controlling the optical dynamics of and excitation-energy transport in supramolecular arrays and 2) studying charge and spin transport in nanostructured, organic semiconducting devices, with the aim to fabricate controllable single-molecule switches and devices.

Quality

The programme “Advanced Materials” is carried out entirely within the Zernike Institute of Advanced Materials, which comprises, besides the physics groups, the groups working in solid-state chemistry. The task of the QANU panel was to review the physics activities only, although we learned about very interesting examples of collaborations between the two disciplines, e.g., exciton spectra of self-organized porphyrin nanotubes. Among the numerous highlights are certainly the experiments on electron spin transport and spin precession in single graphene layers at room temperature, and the seminal theoretical work on multiferroics. The latter appeared as a review article also including experiments in Nature. The groups of this programme are also at the forefront of research in designing new types of complex artificial materials, combining, e.g., organic and inorganic layers. The formation of a focus group on organic solar cells shows great

promise, but this field is very competitive on the international scale with very large and highly competent groups.

Productivity

The productivity is very high and, perhaps even more importantly, is highly recognized by the international community. The Zernike institute is listed as Europe's number-one institution in the Times Higher Education Ranking in materials science in terms of citations per publication in the time span 1999-2009.

Relevance

The activities of the programme to find, characterize, and investigate new materials with electronic functionalities is highly relevant for possible future technologies. While the outcome of course is uncertain, the approach taken by the programme appears to be original also from the perspective of "new physics". The choice of materials is very attractive as a test bed for future electronic devices.

Viability

The prospects of the physics groups working on Advanced Materials are certainly very high. The design of novel materials, combined with state-of-the-art nanofabrication and experimentation techniques, will very likely lead to new materials and possibly to new and unexpected phenomena in these materials. During the site visit, we learned about the initiative toward a free-electron laser in the soft x-ray regime. This would constitute a very important extension of the experimental techniques presently available at the Zernike Institute. Therefore, the scientific case from this point of view is very convincing. The realization, however, hinges on the further development and prioritization of large-scale facilities within The Netherlands.

Conclusion

The performance of the programme Advanced Materials at the Zernike Institute is outstanding in every respect.

Programme RUG 2: **Theoretical High Energy Physics - CTN**
Programme leaders: Prof. E.A. Bergshoeff
Research staff 2009: 8.9 fte

Assessments: Quality: 5
 Productivity: 4
 Relevance: 4
 Viability: 5

The research programme Theoretical High Energy Physics is embedded in the Centre for Theoretical Physics (CTP). The two other programmes, Theory of Condensed Matter and Computational Physics are part of the Zernike Institute for Advanced Materials and evaluated there. The programme Theoretical High Energy Physics comprises three sub programmes: Quantum Gravity, Field Theory and Particle Physics, and String Cosmology.

The Theoretical High Energy Physics programme attempts to describe physics at small (sub-nuclear) and large (cosmological) distance scales, an Ansatz called the Quantum Universe. Theory will soon be confronted with new experimental results both at small distances (the LHC at CERN) and large distances (the Planck satellite). The research in the three sub programmes covers a different distance scale in physics. In the framework of the research into the Quantum Universe the group collaborates with the Kapteyn Astronomical Institute and the KVI.

The Quantum Gravity group is playing a leading role in the development of string theory and its applications in condensed matter systems, cosmology and particle physics.

The Field Theory and Particle Physics group works on non-abelian gauge theories, on the role of supersymmetry in the restoration of conformality, on the study of the strong interaction, and on models of physics beyond the Standard Model to be studied at the LHC.

String Cosmology relates theoretical particle physics and cosmology with the newest precision observations of the cosmic microwave background and the survey of large scale structures in the universe. The String Cosmology group started only recently.

Quality

The group is internationally among the few leaders in Quantum Gravity and string theory. In string theory it was one of the first to highlight the importance of the concept of membranes as an extension of the string concept. This development of brane theory has in a major way influenced string theory and mathematical physics. In recognition of these achievements the Royal Netherlands Academy of Arts and Sciences (KNAW) has appointed in 2010 E.A. Bergshoeff, the leader of the group, as Academy Professor.

The recent addition of String Cosmology has led to a widening and further strengthening of the research profile of the group. Some of the work has become a standard reference and has attracted a lot of attention.

Productivity

The productivity of the group has been very good in all three subprogrammes.

Relevance

The research focuses on the understanding of the origin and the evolution of the universe and thus of high cultural relevance. The techniques developed for string theory and quantum gravity

are of relevance for other for different fields of physics, such as material science. This cross-fertilisation is one of the goals of the group.

Viability

The appointment of E.A. Bergshoeff as Academy Professor provides funds for 5 years to the CTN, enabling the institute to appoint an additional professor. It is the intention to fill this position with a scientist working in the field of condensed matter physics, e.g. by using tools of string theory.

The group is engaged in the creation of a ‘Virtual Institute of Theoretical Physics’ in Groningen in order to further strengthen the activities in this field and to increase its visibility.

Conclusion

The members of this programme have been doing very interesting and imaginative work of high international visibility. As a consequence, E.A. Bergshoeff has been appointed as Academy Professor in 2010.

Programme RUG 3: **Isotope Research**
Programme director: Prof. H.A.J. Meijer
Research staff 2009: 5.0 fte

Assessments: Quality: 4
 Productivity: 5
 Relevance: 5
 Viability: 4

The group performs energy- and environment-related research, in which isotope measurement expertise plays a key role. The research is conducted in four subgroups:

¹⁴C and paleo-environment: This subgroup provides dating services to other scientific groups. It primarily investigates the relation between ¹⁴C and climate.

Atmospheric greenhouse gases: This subgroup aims at understanding and quantifying the carbon balance on several scales of the globe. A major part of the work is focused on fossil fuels.

Water isotopes in the global water cycle: This subgroup performs isotope analyses on ice cores in Spitsbergen and studies the influence of diffusion on the isotope signal in laboratory and field experiments.

Biological/medical behavioural and energy studies: The main goal of this subgroup is to measure energetic costs of specific types of behaviour of free-living animals in a great variety of circumstances. Since 2009, the research goals are shifting towards energy-balance related human health issues.

Quality

The group performs very good environment related research, based on excellent isotope measurement capabilities. As the research and analysis methods are of relevance for very different fields of science such as archaeology, climate research and energy-balance in biological systems it is truly interdisciplinary. The group is one of the oldest and most prominent ¹⁴C dating laboratories in the world and operates the only ¹⁴C accelerator mass spectrometer (AMS) in the Netherlands. This is in high demand by outside users, generating substantial income for the operation and improvement of the facilities. From a physics point of view one of the special strengths of the group lies in the sample preparation and in the development of new and sensitive analysis methods and their applications. The group operates major analytic facilities, necessary for accurate long-term monitoring.

Productivity

The productivity has been very high in terms of cited publications, in a major part through the work on ¹⁴C dating, but equally also in the other fields. The group has developed a truly novel measurement technique for stable water isotope ratios through optical spectroscopy. Due to its size this newly developed equipment can be used in field research and thereby will have a major impact on water research.

Relevance

The main relevance of the work is in the field of climate research, monitoring and climate history (e.g. through isotope composition of ice cores), all of which are of greatest societal relevance. The installation of remote sensing platforms in two locations is giving access to data of a new quality. The relevance of the analytic infrastructure is illustrated by a large income through contracts with scientists from outside institutions.

Viability

The activities of the group were recently integrated in the Energy and Sustainability Research Institute Groningen, combining the Centre for Isotope Research, the Centre for Energy and Environmental Studies, Combustion Technology, Ocean Ecosystems, Geo-Energy with a Science and Society Group. This establishes a broad platform for future research in the field of energy and sustainability, for example through intensified cooperation with ocean system group and with the Geo-energy group (on carbon capture and storage). Through the sector plan a new group for modelling of the atmospheric composition is being established which will significantly strengthen the group. The group is participating in establishing a European integrated carbon observation system. On the other hand, one key scientist has left the group in the field of water isotope research and the vacancy is being blocked, endangering the future of the related research. The continuous operation, maintenance and upgrades of the analytic facilities are difficult in a university environment and deserve the necessary support.

Conclusion

The work of the group is of truly interdisciplinary character and of great relevance for climate research. Through the development and operation of highly sensitive analytic methods the group is very visible and attracts many users.

Programme RUG 4: **Atomic and Subatomic Physics**

Programme leader: Prof. K. Jungmann

Research staff 2009: 41.4 fte

Assessments:	Quality:	4
	Productivity:	4
	Relevance:	4
	Viability:	3

The mission of the group is to pursue high quality, innovative, front-line research in fundamental and applied atomic and subatomic physics in experiment and theory. In 2009 KVI has set the objective to focus its research further and to concentrate its manpower on two scientific spearheads:

1. Research on fundamental interactions and on symmetries in nature in precise experiments
2. Applications of the methods and instrumentation that have been developed in connection with the fundamental research into highly relevant societal issues.

KVI is the only remaining accelerator laboratory in the Netherlands, with successful research in nuclear structure physics, hadron physics, atomic physics and fundamental symmetries. The work is internationally embedded and KVI-scientists participate in the European coordinating group for nuclear physics (NuPECC) and in the long-range planning in subatomic physics. In 2005 the funding agency FOM decided to end its support of Nuclear Physics, but continued to fund precision measurements of fundamental interactions in trapped radioactive isotopes, produced by the superconducting cyclotron AGOR of KVI. This programme which started in 2001 has now reached a point where first data have been taken and published. AGOR is also used for radiobiological research and medical physics experiments.

The KVI is an interfaculty institute at the University of Groningen and as such fully integrated in the educational programme. KVI, with a support staff of about 65 people, represents a major research asset through its various technical skills, required to build and operate a major research infrastructure.

The research is conducted in six subgroups:

1. Fundamental Interactions and Symmetries (TRI μ P): The TRI μ P facility is used to measure with very high precision key parameters of the Standard Model through atomic parity violation in radioactive ions. In the preparation phase a number of novel techniques were developed to achieve the required accuracy.

2. Atomic and Molecular Physics (AMO): The work of the group on Atomic and Molecular Physics studies processes induced by highly charged ions in atoms, bio-molecules and on surfaces, the latter being of importance for diagnostics and understanding of fusion and astrophysical plasmas.

3. Theoretical Subatomic Physics (TSP): The group on Theoretical Subatomic Physics works on questions of the Standard Model, with an emphasis on testing the fundamental symmetries and on hadron physics, in collaboration with the experimental programme of the KVI. It collaborates with the Centre for Theoretical Physics (CTN).

4. Accelerator Physics (ACC): Next to its primary task to provide beams for the users of the AGOR cyclotron and improve the performance of the facility to meet the needs of in particular the

TRI μ P programme, the group on Accelerator Physics has a research programme on the application of particle beams for radiation therapy. They are part of a KVI-UMCG initiative to build a centre for proton beam therapy, with VU University and University of Twente.

5. *Hadron and Nuclear Physics (HNP)*: The Hadron and Nuclear Physics group puts its emphasis on the studies of exotic nuclei and the structure of hadrons. The research is pursued in collaboration with other nuclear research centres at their facilities, such as the GSI in Germany.

6. *Astroparticle Physics (APP)*: In the field of Astroparticle Physics KVI collaborates closely with Nijmegen in Pierre Auger. KVI proposed the use of radio antennas to detect and measure the properties of ultra-high energy cosmic rays, and now leads this activity.

In view of the fact that AGOR operation will stop being funded in 2014, KVI, together with scientists from the Zernike Institute, has developed the plan to build and operate a Free Electron Laser in the soft x-ray domain. The proposal is close to being completed and submitted for funding.

Quality

The overall quality of the research at KVI is very good and in two subprogrammes (Fundamental Interactions and Symmetries and Astroparticle Physics) excellent.

Productivity

The productivity was very good, but reflects the fact that the TRI μ P facility required a lot of preparatory work and has not yet started its main data taking. Furthermore, high precision experiments are requiring a lot of time and effort. Nevertheless, a substantial number of papers were published. In the opinion of the reviewers the productivity has also been negatively influenced by the fact that KVI has focussed a lot of effort on developing a long-term strategy.

Relevance

The research focuses on a number of topics of different degrees of societal relevance. The understanding of the fundamental symmetries in nature is of cultural and educational relevance. The detector techniques developed around the accelerator are of relevance for other fields of science. The research programme on the application of particle beams for radiation therapy has medical relevance. The treatment of a large number of cancer tumours per year has very direct relevance.

Viability

The future of the large infrastructure at KVI has been uncertain for some time because there seems to be a lack of a consistent nationwide strategy concerning large research infrastructure, including establishing a transparent process on how to select such an infrastructure and on how to fund its construction and sustained operation. Other European countries could serve as examples for similar scientific and political decision processes. The KVI has been and still is a strong national infrastructure and forms a pool of competence. It should be given clear indications in which way to develop and under which financial boundary conditions.

Conclusion

In the opinion of the reviewers the situation and productivity of KVI have been negatively influenced by the uncertainty of the future of the institute. A few years ago the funding agency FOM decided to withdraw from the nationwide funding of traditional nuclear physics. This decision affected a large part of the KVI activities, even though this type of research continues to receive funding from non-national sources. At present KVI is the only accelerator laboratory in

the Netherlands and as such a major national infrastructure. The impression of the reviewers is that there exists no clear political strategy on future large research infrastructure in the Netherlands, that no process is put into place on how to decide on new structures and that no consistent plan exists on how to fund their construction and operation.

In close cooperation with the Zernike Institute for Advanced Materials, KVI has developed a plan to build a free electron laser in the soft x-ray domain (ZFEL). In the opinion of the reviewers the exciting scientific possibilities of such a device are out of question. However, such a major scientific and technological challenge can only be successful if the responsible parties take a true long-term commitment and provide adequate funding for construction and operation. Without this, the viability of KVI and ZFEL is at stake.

4A. INSTITUTE LEVEL - University of Twente

University: University of Twente
Faculty: Faculty of Science and Technology

1. The institute

The University of Twente (UT) organizes its research in a matrix structure of Faculties and Research Institutes. The Faculties are responsible for the educational programmes, financial administration, and human resources. Scientific personnel are employed by the faculty. The Research Institutes are responsible for the long-term strategic research plans and research programmes (strategic research orientations). The scientific directors receive the integral research budget for their institute, and are responsible for the allocation of this budget over the chairs in the institute.

The department of Applied Physics is embedded within the Faculty of Science and Technology of the UT. The research of all Applied Physics groups in the faculty is embedded within one or more multidisciplinary research institutes. During the review period, the institutes of relevance to Applied Physics research groups were the MESA+ Institute for Nanotechnology, the MIRA Institute for Biomedical Technology and Technical Medicine (successor of the BMTI Institute for Biomedical Technology), and the IMPACT Institute for Energy and Resources.

The University is currently reviewing its strategy and portfolio of research and education; it is likely that in the course of this review the IMPACT institute will be disbanded, and that all Applied Physics research carried out within IMPACT will be re-embedded within either MESA+ or MIRA.

The research comprises three focus areas:

- Fluid Physics,
- Materials Physics, and
- Optics and Biophysics.

Each focus area comprises several research groups:

Fluid Physics:

- Computational Biophysics (CBP)
- Physics of Complex Fluids (PCF)
- Physics of Fluids (POF)

Materials Physics:

- Computational Materials Science (CMS)
- Low Temperature Physics (LT)
- Solid State Physics (SSP)

Optics and Biophysics:

- Biophysical Engineering (BPE)
- Complex Photonic Systems (COPS)
- Laser Physics and Nonlinear Optics (LPNO)

- Optical Sciences (OS)

In anticipation of the impending retirement of some of the senior staff, and consistent with its vision to create smaller and more focused research groups, the department have streamlined the structure of the largest groups, and recruited new staff members. The most significant changes (effective 2010) are:

- Splitting the Biophysical Engineering group into 1) Nanobiophysics, 2) Medical Cell Biophysics and 3) Biomedical Photonic Imaging
- Splitting the Low Temperature Physics group into Interfaces and Correlated Electron Systems and Energy, Materials and Systems
- Incorporating the Solid State Physics group into Physics of Interfaces and Nanomaterials:
- Recruitment of Prof. Serge Lemay (Nanoionics) and Prof. Claudia Filippi (Biomolecular Electronic Structure)

Assessment/remarks

The Committee acknowledges that the multidisciplinary research institutes play a role in defining the direction of the research, in stimulating joint efforts and in maintaining adequate infrastructural facilities such as the cleanroom and instrumentation for medical imaging. The administrative complexity of this matrix structure remains a point for attention.

2. Quality and academic reputation

The Department plays a leadership role in national initiatives as such as NanoNed, NanoImpuls, MicroNed, and the new national Nanotechnology programme, NanoNext.NL. The Department leads and participates in national research programmes such as FOM ‘top-down’ and ‘free’ programmes, SmartMix and IOP initiatives and in national networks such as the J. M. Burgers Centrum, the Dutch Polymer Institute, and the Research School integrated Biomedical Engineering for restoration of Human function (iBME). Several members of the Department are members of editorial boards, and national and international review panels.

Internationally the Department participates in European Union Framework Programme Networks of Excellence and research grants, ERANET actions, the Human Frontiers Science Programme research grant initiatives, and bilateral initiatives between NWO and other countries. Staff members have served as coordinators for the FP6 Network of Excellence FRONTIERS.

The self-evaluation report furthermore mentions that external collaborations with industry are essential elements of Technology Foundation (STW) grants, and FOM Industrial Partnership Programmes. Industrial support of research (contract research) is an important element of the research funding, and involves both large multinational industrial partners and small and medium scale enterprises. Individual staff members maintain vibrant external collaborations, including formal links to other institutions.

Indicators of academic reputation include 2 Spinoza prizes, a Simon Stevin Master Award, and ERC Advanced Grant, 2 memberships of the Executive Board of FOM, 7 memberships and chairs of advisory committees for scientific research subfield within FOM, 2 KNAW memberships and 4 *De Jonge Akademie* memberships.

Staff members of the Department received 7 VENI, 9 VIDI and 8 VICI grants and various scientific prizes and fellowships. The Department participates in several 3TU Centres of Competence and the Centres of Excellence on Multiscale Phenomena, Bio-Nano Applications and Sustainable Energy Technologies.

In addition, the self-evaluation report argues that the increasing number of PhD candidates who are supported by projects granted by the Foundation for the Fundamental Research on Matter (FOM) indicates the growing appreciation of the Applied Physics programme at Twente.

Assessment/remarks

The quality of the UT programmes under review was assessed as very good to excellent. There is a slight differentiation in the quality assessments of the subprogrammes within the clusters.

3. Resources

The self-evaluation report emphasizes that as a consequence of planned retirements and staff mobility there has been a significant renewal of permanent staff, both at professorial and junior and senior staff levels, in the past six years. During this rejuvenation process, the Department has been fortunate in attracting excellent female candidates.

A new cleanroom, NanoLab NL, was recently opened (Nov. 2010).

The University is developing a tenure-track system for young scientific talent, which the Faculty of Science and Technology has been proactive in establishing.

The self-evaluation states that the Department has been very successful in attracting research funding from external sources, such as NWO, FOM, the Technology Foundation (STW), and the European Union.

Assessment/remarks

The panel found the facilities generally of a very high level, and was especially impressed by the well-managed MESA+ facility in the area of nanostructures.

4. Productivity

The results of the CWTS-analysis show that the Twente programmes under review have produced 1400 articles in Web of Science journals in the 4 years of the review period. These articles were cited 11009 times, not counting self-citations. The mean citation score is 10.07 for Fluid Physics, 10.38 for Material Physics, and 13.34 for Optics & Biophysics. The highest number of papers among the 10% most frequently cited papers is 19 for the groups Fluid Physics and Optics & Biophysics. The number of articles per full-time equivalent of academic staff ranges from 0.7 to 3.1 for in the subgroups in the UT programmes under review.

Assessment/remarks

The UT programmes under review have received high marks for productivity.

5. Societal Relevance

The UT prides itself on being an “entrepreneurial” university, and as such actively stimulates the commercialization (‘valorisation’) of research results, in order to make a broader impact on society and the regional and national context. According to the self-evaluation report, relevant applied research is a key component of the Applied Physics portfolio, and the researchers are involved in numerous collaborations with industry. These collaborations are in the context of industry-sponsored research, IPP programmes, and STW grants. Key industrial partners include BP, Shell, Océ, Philips, ASML, and a host of small and medium enterprises.

The self-evaluation report argues that the relevance of the applied research for industry is reflected in successful grant applications to the Technology Foundation (STW), FOM Industrial Partnership Programmes (IPP), and industry-sponsored research.

Assessment/remarks

The Committee fully endorses these observations. The societal relevance of the UT programmes under review is assessed as very good to excellent.

6. Strategy for the future

UT focuses on excellence in the spearhead areas of nanotechnology, biomedical technology, sustainable engineering, information and communications technology, and governance. The research domains of the Applied Physics groups are broadly aligned with the first three of these areas, and in the coming years the Department will further focus its research directions to fit with the University's strategy.

The self-evaluation report explains that since the research groups are the key autonomous units of the organization, possible changes will have to occur at the level of the research chairs. While the strategic discussion is still ongoing, certain elements of what is required from each of the research chairs in the future are evident:

- Direct funding is expected to be reduced, so research groups will have to further intensify their activities to generate grant funding from the 2nd and 3rd money streams. Research groups will have to stimulate their staff to apply for NWO Innovational Research personal grants and ERC Starting and Advanced Research grants.
- Collaborations with industry will become increasingly important, as will interdisciplinary collaborations, in order to be able to tap into other funding sources (such as private funding charities that substantially fund biomedical research).

To generate external funding the Department will focus on the opportunities for interdisciplinary collaborations within its institutes and pursue strategic collaborations with other universities in the North-East Netherlands (University of Groningen, Radboud University Nijmegen, and Wageningen University) and in Germany. Moreover, the Department aims to enhance the attractiveness of the Applied Physics education to school-leaving students. The Sector Plan will be used to strengthen the research in Fluid Physics, and to actively attract female scientific talent.

Finally, Applied Physics will also actively seek to increase international collaboration. The self-evaluation report mentions that MESA+ is in the process of forming an international network of world-class nanotechnology institutes. Participation in other international frameworks will also be pursued.

Assessment/remarks

The Committee regards the increasing focus on nanotechnology, biomedical technology and sustainable engineering as a very good choice that can offer fruitful opportunities for all kinds of internal and external cooperation.

7. PhD Training

For PhD students, a formal development and supervision plan is set up at the beginning of a project and evaluated yearly.

The Twente Graduate School (TGS) provides coherent and integrated graduate research programmes for MSc and PhD education. At this moment, the TGS programmes in

Computational Science, Fluid Physics, Advanced Optics, Nano- Devices and Systems, Next Generation Energy and Resources, and Novel Nanomaterials have active participation from Applied Physics groups.

Each Graduate Research Programme in the School is headed by a Programme Leader which is responsible for the coherence and the quality of the specific programme. He oversees the graduate students' progress and the rules and regulations governing graduate education at the UT.

The self-evaluation report provides a summary of the number of PhD degrees completed and in progress. On average, 32% of the PhD students graduate within 4 years, 72% is graduated after 5 years, and 84 % after 6 years. The Department strives to increase this success rate and to decrease the time to PhD to the nominal 48 months.

Assessment/remarks

The Committee encountered an enthusiastic and highly motivated group of PhD-students. There were no complaints about their training opportunities and supervision.

4B. PROGRAMME LEVEL - University of Twente

Programme UT 1: **Fluid Physics**

Programme directors: Prof. W.J. Briels (CBP), Prof. F. Mugele (PCF, since 11/2004), Prof. J. Mellema † (PCF, until 03/2004), Prof. Detlef Lohse (POF)

Research staff 2009: 45.29 fte

Assessments:	Quality:	5
	Productivity:	5
	Relevance:	4.5
	Viability:	5

The Fluid Physics programme comprises three subprogrammes: Computational Biophysics (CBP), Physics of Complex Fluids (PCF), and Physics of Fluids (POF).

Overall scores for subprogrammes:

CBP:	4.5
PCF:	4.5
POF:	5

- *Computational Biophysics (CBP)*

The objective of the research conducted by the CBP group is to understand structure formation and self-assembly of synthetic and biological polymers in relation to their rheological properties in order to assist in developing tailor-made soft matter systems. The main research activity of the programme is to develop mesoscopic models that incorporate the essential physics and allow computer simulations of systems that are large enough to exhibit the processes of interest. The implied coarse graining is done both bottom-up and top-down. The physical questions that the group addresses are all concerned with properties of soft matter systems.

- *Physics of Complex Fluids (PCF)*

The goal of the PCF group is to understand and control the structure and the mechanical properties of liquids and interfaces on length scales ranging from molecular to submillimeter scales. This involves the liquid behaviour confined in nm scale, the dynamics of contact line, the microscopic structure at the three-phase contact line, and the complex rheology of soft matter.

- *Physics of Fluids (POF)*

The POF group works on a variety of problems in the fundamentals of fluid mechanics. The main areas of research are: 1) turbulence and multiphase flow, 2) granular matter, 3) micro- and nanofluidics, and 4) biomedical flow. Experimental, theoretical, and numerical methods are used, and the work of the group is characterized by a combined approach of these methods. The objective is an understanding of the physics that governs the observed phenomena. On the experimental side the key expertise of the group lies in high-speed imaging.

Quality

The CBP group has produced many innovative models to simulate the complex flow behaviours of polymers solutions, micellar solutions, lipid membranes, and colloidal suspensions, in collaboration with international (academic and industrial) partners. Especially, they produced a novel and successful model which can simulate the non-linear viscoelastic flow of entangled polymeric systems. Their recent work on the self-assembly of clathrins is also attracting considerable attention in the community.

The PCF group is best known for their leading role in wetting (especially electro wetting) and its application in microfluidics. Electro-wetting has seen many applications in active lenses, lab-on-a-chip systems, and displays etc. The control of liquid flow on a substrate is becoming increasingly important in modern technology such as coating, printing, chip fabrication processes, and also in large-scale industry such as oil-recovery. Recent studies have shown that this objective is achieved only by understanding the physics at many length scales (of nanometer, micrometer, and millimeter) and by bridging these. The group is becoming an important part of the MESA+ programme. The group has been playing a key role in many national and international programme and is now acting as one of the three academic partners of BP's ExploResearch programmes on physics on enhanced oil recovery, with 4.25 million EUR funded for the group (duration: 5 years).

The POF group is a renowned group in fluid physics. They have pioneered frontiers of fluid physics, especially fluids containing bubbles, collaborating with many partners in various fields, including engineering, mathematics, chemistry, acoustics, medicine, or biology. This involves not only basic scientific work, but also new applications of their findings. For example, using the facilities of MESA+, they have shown that bubble nucleation is a process perfectly reproducible and predictable by theory. In collaboration with Océ Technologies, they have solved the problem of bubble entrainment in ink-jet printing. Furthermore, they are now developing the use of micro-bubbles for ultrasound imaging, and for diagnostics and therapy. The dynamic expansion and evolution of the research is very impressive.

Productivity

The productivity of the programme is very high. On average, each faculty member has produced 6.5 refereed articles in a high profile journal every year during the period between 2004-2009, and each article is co-authored by about 2-4 people (faculty, students, and outside collaborators). The groups do intentionally not aim at taking patents as it complicates the interaction with companies, is expensive and defocuses from scientific questions, although they have 3 patents during the period.

Relevance

The programme is pursuing physics of fluids which is not covered by conventional fluid dynamics, but strongly needed in many applications. The flow of complex fluids (polymers and colloids) is obviously important in chemical industries, the flow near the interface or the contact line is important in printing, coating and oil recovery, and the flow involving phase change (bubbling and evaporation) is important in drag reduction, immersion lithography, ink-jet printing and ultrasound imaging etc. An important point is that they are not aiming at solving particular problems for industries, but aiming at enhancing common knowledge to solve these problems, and thereby advancing the frontier of fluid physics. Their work is highly regarded by industries as is demonstrated by the number of collaborations with industries and the funds they are receiving from them.

Viability

The three groups are complementary to each other and have proper overlap. They are quite flexible and capable of tackling new problems as they are motivated by physics, not by instrumentation or methodology. They have succeeded to compensate for the decrease of the 1st money stream by attracting funding from external sources (industrial funding and other competitive grants). Recently they succeeded to attract a new faculty member Serge Lemay from Delft to Twente.

Conclusion

The Fluid Physics groups are conducting high quality research on the rheology of complex fluids, nano-micro flow at interfaces, and multi-phase flow with phase transitions. They aim at advancing fundamental understanding of the physics of fluids taking challenges of real world applications. Each group is leading the frontier in fluid physics in their own area. At the same time, there is proper overlap among the groups, which gives them a unique strength. The viable and collaborative environment of the programme is suited to the educational goal ‘to raise creative scientific professionals for the benefit of society’.

The reviewers note that the current situation was realized by intensive efforts from the groups, compensating the deficit by means of fluctuating external sources. This is an unfortunate situation for the groups, who are doing an excellent job in making fundamental contributions to science by solving real-world problems.

Programme UT 2: **Materials Physics**

Programme directors: Prof. P.J. Kelly (CMS), Prof. H. Rogalla (LT), Prof. B. Poelsema (SSP), Prof. H.J.W. Zandvliet (SSP)

Research staff 2009: 52.58 fte

Assessments:	Quality:	4
	Productivity:	4.5
	Relevance:	4
	Viability:	5

The Materials Physics group comprises three sub-groups: Computational Materials Science (CMS), Low Temperature Physics (LT), and Solid State Physics (SSP).

Overall scores for the subprogrammes:

CMS:	5
LT:	4.5
SSP:	4

Computational Materials Science (CMS)

The research of the CMS group focuses on understanding the magnetic, optical, electrical and structural properties of solids in terms of their chemical composition and atomic structure. They do this by numerically solving the quantum mechanical equations describing the motion of the electrons. The ultimate objective is to (be able to) design materials with specified physical properties and functionalities that can be realized experimentally.

Low Temperature Physics (LT)

The central research area of the LT group is Applied Superconductivity. This spans activities from basic research on the electronic properties and materials science of superconductors to application-oriented research covering the development of superconducting devices and systems, including the necessary supporting technologies such as cryogenics.

In this, three major research themes can be distinguished:

- Superconducting electronic logic and sensing devices and thin film materials science;
- High-current superconductors, their applications and cryogenic cooling technologies;
- Biomagnetism research employing superconducting SQUID sensors and other magnetic methods.

The research is in first line experimental, but also involves theoretical studies, modelling and simulations.

Solid State Physics (SSP)

The research of SSP group focuses on an in-depth microscopic and spectroscopic characterization of materials in reduced dimensions. It naturally involves the development of generic, surface physics based methods for the controlled preparation and understanding of the physical (and chemical) properties of these novel nanomaterials.

The research themes range from fundamentally driven to more application oriented ones. The researchers consider the development of ultrasensitive spectromicroscopic techniques with the highest resolution as a prime part of, and an enabler for, their programme.

Quality

The CMS group has a very good record of high-quality papers focusing on density-functional-calculations of materials and devices with electronic functionalities, in particular on magneto-electronics. A recent very timely example is the prediction that Ni-graphene-Ni junctions would be perfect spin filters. The impact of the papers in terms of the number of citations per article of this group is among the highest of all groups that were reviewed.

The activities of the LT group span a wide range of applied-oriented work (superconducting cables, microcoolers) and more fundamentally oriented work with the aim at realizing new electronic functionalities (hybrid structures of low-temperature and high-temperature superconductors, transition-metal oxide interfaces). Concerning the latter, the group has produced high-quality interfaces of $\text{LaAlO}_3/\text{SrTiO}_3$ that had previously been shown to be metallic, and found - together with the high-magnetic-field group in Nijmegen - that a large field can induce magnetism at these interfaces. Altogether, these activities demonstrate the very high quality of this group's research.

The SSP group has pioneered in the investigation of surface structures, where it has a long-standing record of high citation rates. In view of global trends in surface science, the group has taken steps to increase its focus on activities in non-UHV environments. A recent highlight is the demonstration of a Peierls transition, i.e. a periodically modulated distortion of the position of Pt atoms along these chains. The issue of how organic molecules attach to these chains and how their end groups can be lifted with an STM tip, appears to be rather special in view of the many activities worldwide concerning a possible molecular electronics application.

Productivity

The overall productivity of the groups participating in the programme is very high. Publications appeared in a number of highly prestigious journals and along with comprehensive reviews, e.g., on magneto-electronics.

Relevance

The research performed in this programme on new electronic phenomena and functionalities of solid-state heterostructures and devices, including superconducting materials, has a high relevance for future technologies. On the other hand, many of the issues addressed and materials/devices investigated or suggested at the presentation of the programme during the site visit to be studied are subject of many activities worldwide. Of particularly strong impact is the understanding of how to optimize mechanical strength of superconducting cables and junctions for high-field applications in magnets. This is of decisive importance for present and future large-scale installations such as the LHC at CERN and ITER at Cadarache.

Viability

The programme, previously organized in three chairs, has been restructured to meet the future challenges of competitive research by forming smaller groups being able to take up new activities more flexibly. The review panel was convinced that this measure is very suitable to meet the research challenges of the future. Much of the work on electronic functionalities is based on the MESA+ facility. The panel was strongly impressed not only by the sheer size of this facility and its manifold opportunities to fabricate and characterize nanostructures but also by the highly professional way it is run. This holds great promise for the future activities of the programme. This might be the reason why the presentation given during the site visit contained more projects for the future than actual results

Conclusion

The programme Materials Physics, in its intention to span the range from fundamental issues of solid-state physics to more material-oriented issues, including simulations and theoretical modelling, has performed very successfully and has achieved a number of noteworthy results. The excellent facilities offer great opportunities for the future.

Programme UT 3: **Optics & Biophysics**

Programme directors: Prof. V. Subramaniam (BPE, from 03/2004), Dr. C. Otto (BPE, interim chair until 03/2004), Prof. W.L. Vos (COPS), Prof. K. Boller (LPNO), Prof. J.L. Herek (OS, since 2006), Prof. N. van Hulst (OS, until 2006)

Research staff 2009: 52.19 fte

Assessments:	Quality:	5
	Productivity:	5
	Relevance:	4.5
	Viability:	5

The Optics and Biophysics programme comprises four subprogrammes: Biophysical Engineering (BPE), Complex Photonic Systems (COPS), Laser Physics and Nonlinear Optics (LPNO), and Optical Sciences (OS).

Overall scores for the subprogrammes:

BPE:	5
COPS:	4.5
LPNO:	3
OS:	5

Biophysical Engineering (BPE)

- a) Molecular and cellular biophysics (quantitative visualization and manipulation of molecular and cellular biophysical processes at high spatial, temporal, and chemical resolution, using innovative new optical and nanotechnology-based tools)
- b) Biomedical optics (the interaction of light with tissue for non-invasive tissue diagnostics, aiming to develop new diagnostic tools that are non-invasive or minimally invasive, and to enable translational research and application in a clinical setting)
- c) Medical cell diagnostics (the detection of circulating tumour cells using flow cytometric principles).

Complex Photonic Systems (COPS)

The Complex Photonic Systems group aims to control light and optical processes in nanophotonic structures. The group initiated experiments on photonic bandgap crystals, and has pioneered inverse opals, the most powerful crystals for visible light. The group has opened a new field of research by shaping wavefronts to focus light in or beyond opaque media and has performed pioneering studies on Anderson localization and diffusion of light. Its present research goals are:

- To focus light deep inside opaque metamaterials.
- To develop innovative imaging methods based on the control of optical wavefronts.
- To demonstrate “sweet spots” in photonic metamaterials where quantum systems such as quantum dots experience greatly enhanced or strongly inhibited light-matter interaction.
- To realize functional 3D photonic bandgap crystals with high-Q cavities by CMOS-compatible methods. To switch the properties of cavities at ultimate repetition rates and speeds.
- To have light propagate over unprecedented distances across imperfect photonic circuits.
- To explore novel opportunities for applications and fundamental science using interference in complex media.

Laser Physics and Nonlinear Optics (LPNO)

The Laser Physics and Nonlinear Optics group actively participates in research on and in development of photonics via the generation and manipulation of coherent light in improved and novel ways with an emphasis on the nonlinear interaction of light with matter. The main areas of research are

- Continuous wave optical parametric oscillators
- Generation and manipulation of coherent extreme ultraviolet light and x-rays
- Innovative accelerator and free-electron laser concepts
- Integrated linear and nonlinear photonics

Experimental research is supplemented with theoretical and numerical analysis. Part of the research addresses novel concepts, e.g., involving extreme light intensities for laser wakefield acceleration with improved beam properties, on-chip passive mode-locking of an array of coherent light emitters, and on-chip optical parametric oscillators. The group also performs application driven research. Examples are continuous wave mid-infrared optical parametric oscillators for covering the spectral finger-print region for many molecules, nano-structured x-ray optics for improved x-ray imaging and high-order harmonic generation for seeding of soft x-ray free-electron lasers.

Optical Sciences (OS)

The mission of the Optical Sciences group is to develop and apply innovative optical methodologies for the characterization and control of biomolecules and nanostructures, in particular where fundamental insights can lead to new technologies.

The group studies the interaction of light and matter at the nanoscale by exploring ways to shape light and its environment using various strategies for active and passive control. Active control involves real-time manipulation of the light-matter interaction via shaped light pulses. By tailoring the amplitude and phase profile of broadband (femtosecond) pulses, the group can enhance chemical selectivity in nonlinear spectroscopy and imaging, as well as remove non-resonant background signals. Coherent control strategies employ pulse shapers in a closed-loop optimization experiment, aimed at manipulating quantum interferences to create a desired outcome, such as efficiency or selectivity. Alternatively, by passively controlling the environment, the group creates structures that interact with light in new ways. Metal nanostructures, antennas, and designer gratings are explored in terms of both fundamental physics and application potential.

Quality

The programme has a large variety of research topics, but there is a “sense of coherence”: Some groups focus on methods or theory and modelling, others on particular biomedical questions, a mix which leads to synergistic effects within and between the subprogrammes. The groups are internationally well recognized, especially the programme directors, e.g. Niek van Hulst, who recently left to join the new ICFO Institute near Barcelona, for his nano-biophotonics work, or Cees Otto for his profound Raman micro-spectroscopy work. The new “next generation” team (Subramaniam, Manohar, Vos, Herek, Offerhaus and co-workers) has already published some very original work, and it is expected that more is to come in this spirit. The work to be evaluated was rated excellent in general, however, some weaker spots exist, e.g. in the subprogramme LPNO (which might merge with another subprogramme, e.g. OS, since it seems to already have been converging towards this subprogramme and supporting it; there already exist joint publications).

Productivity

The productivity of the programme is generally high (OS leading with an excellent MNCS of 3.48), but input and output are not entirely homogeneously distributed among the different subprogrammes. The productivity cannot only be assessed in terms of publications, since patents and spin-off activities, e.g. related to R&D in microscopy systems, are also important in this field and have to be taken into account.

Relevance

The programme addresses many important issues, especially the biomedical goals of BPE have potentially high impact in society. Yet there are large differences among the various research projects: some pursue long term goals of an interdisciplinary kind, trying to get answers using any possible experimental, methodological or theoretical support that is locally available, while in some projects (e.g. in OS and COPS) slightly “opportunistic” tendencies are emerging, i.e. going for a “fast success” and aiming at a high impact publication of fashionable aspects of a research theme, rather than going the slower (and nowadays less rewarding) way towards more sustainable research results.

Viability

There has been a considerable turnover in PIs in the last few years, but the current, relatively young team seems to be extremely keen to do science together. This spirit of team-work was clearly noticeable and is a strong asset of the programme. A graduate school “Advanced Optics”, closely related to the optics research activities, has been created to attract students, which is important, since lack of students was identified as a problem in the self-evaluation.

The complicated matrix structure sometimes leads to bureaucratic complications, but the scientific advantage that it creates by “forcing” the researchers to interact with each other seem to outweigh this. Nevertheless, it might pay off to think about how to keep the good aspects while slightly streamlining the bureaucratic procedures.

Conclusion

The programme has produced excellent results and has a young and enthusiastic team. Strengthening the synergistic effects within the programme even further, accompanied by some more focus, could make the entire programme even stronger.

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5A. INSTITUTE LEVEL - Radboud University Nijmegen

University: Radboud University Nijmegen
Faculty: Faculty of Science

1. The institute

The Faculty of Science of the Radboud University Nijmegen has three interdisciplinary research institutes without specific Physics components:

- the *Institute for Water and Wetland Research* (IWWR),
- the *Institute for Computing and Information Sciences* (ICIS),
- the *Institute for Science, Innovation and Society* (ISIS),

and three institutes with a Physics component:

- the *Institute for Molecules and Materials* (IMM), the aim of the IMM is to design, synthesize, grow, and study molecules and materials in order to understand and control their properties and to design new functionalities.
- the *Institute for Mathematics, Astrophysics and Particle Physics* (IMAPP), performing research on the foundations of mathematics, astrophysics and particle physics in order to push the boundaries of knowledge on the origin and evolution of the universe.
- the *Donders Centre for Neuroscience* (DCN), part of the Donders Institute of Brain, Cognition and Behaviour (DI), a platform including all research groups of the Radboud University Nijmegen that are active in the field of Neuroscience.

Three research groups or clusters are included in the 2011 research evaluation:

- Physics of Molecules and Materials, part of the Institute for Molecules and Materials (IMM). From the 21 research groups in the IMM, the 9 physics groups together are evaluated as one single programme in this assessment.
- High-Energy Physics, part of the Institute for Mathematics, Astrophysics, and Particle Physics (IMAPP)
- Biophysics, part of the Donders Centre for Neuroscience (DCN).

Institute for Molecules and Materials (IMM)

The IMM moved in 2006 to the modern Huygens building. The self-evaluation report states that the proximity of all research groups has stimulated interdisciplinary collaborations. New laboratories have been established for the large research facilities, such as the High Field Magnet Laboratory (HFML), the Nuclear Magnetic Resonance (NMR) pavilion and the *Nanolab*.

The staff members are employed by the research institute, but spend 40% of their time on teaching. The staff of the IMM takes part in four master's programmes: Natural Science, Molecular Life Science, Chemistry and Physics and Astronomy.

Institute for Mathematics, Astrophysics and Particle Physics (IMAPP)

IMAPP's research is fundamental in nature and lays emphasis on interdisciplinary research, particularly in astroparticle physics and mathematical physics.

IMAPP is organized in six departments, two of which are subject to the 2011 research evaluation:

Theoretical and Experimental High-Energy Physics. These two departments present one joint programme for this review: High-Energy Physics.

Joint research programmes exist for cosmic ray astrophysics at the Pierre Auger Observatory for Experimental HEP and the Astronomy departments and for the application of noncommutative geometry to gauge theories for the Theoretical HEP and Mathematical Physics departments.

Donders Centre for Neuroscience (DCN)

The DCN is an interfaculty centre and comprises research departments from both the Faculty of Science (i.e. the Dept. Biophysics, Depts. Molecular Animal Physiology and Cellular Physiology), and the University Medical Centre St. Radboud (Cognitive Neuroscience, Otorhinolaryngology, Neurology, Human Genetics, and Psychiatry). The DCN is part of the Donders Institute of Brain, Cognition and Behaviour (DI), a platform including all research groups of the Radboud University Nijmegen that are active in the field of Neuroscience, which was established in September 2008.

The research mission of the DI is to perform innovative, multidisciplinary and internationally competitive research at the forefront of Neuroscience, and to train graduate students into the functioning of the central nervous system, both in the normal brain, and in relation to neurodegenerative disorders. The research is carried out from a fundamental scientific (experimental and theoretical), as well as from a medical applied perspective. The research encompasses all levels to approach the study of cognitive neuroscience, ranging from genes and molecules, via cells and networks of cells, to cognitive systems and behaviour.

The DCN contributes to three of the four research themes of the DI:

- Perception, Action and Control (Biophysics)
- Learning, Memory and Plasticity
- Brain Networks and Neuronal Communication (Biophysics).

Assessment/remarks

This review is limited to the physics research in the interdisciplinary institutes of RU, but it is obvious that the institutes provide a significant added value to these programmes.

2. Quality and academic reputation

The self-evaluation report provides a list of high-impact publications, personal grants and awards, research grants. These are taken into account in the programme assessments. Some highlights are:

IMM

In November 2010, the 2010 Nobel Prize in physics was awarded to Prof. Geim and Prof. Novoselov from the University of Manchester. Geim has been associate professor within the HFML and Novosolev obtained his PhD at the Radboud University Nijmegen. Prof. Geim is an Extraordinary Professor at IMM.

IMAPP

IMAPP's Experimental High-Energy Physics department was one of the founders of the Dutch National Institute for Subatomic Physics in 1975, known as Nikhef. The Theoretical High-Energy Physics department has been part of Nikhef since 2005. This led to the Radboud University Nijmegen taking a prominent position within Nikhef and to a better embedding of the Theoretical High-Energy Physics research carried out within IMAPP. Because Nikhef has the

mass to play a leading role in a number of large experiments in worldwide collaborations, the experimental HEP department has substantial impact in the experiments they participate in.

DCN

In the past six years more than thirty papers were published in Journals with an impact factor higher than 9 including Nature (2), Nature Genetics (6), Science (2), Cell (1), Lancet Neurology (4) and Neuron (3). Prof. Bloem (Neurology) is a recognized world-leading researcher in Parkinson's disease, and founder of the Dutch ParkinsonNet.

Assessment/remarks

The quality of the RU programmes in this review was assessed as very good to excellent.

3. Resources

IMM

The self-evaluation report states that the national and international position of the IMM is strengthened by the presence of a number of large-scale experimental research facilities, including:

- High Field Magnet Laboratory (HFML) for continuous fields up to 33 Tesla (with the ambition and funding to realize 38 Tesla in 2012 and 45 Tesla in 2014). The HFML is recognized as a national research facility by FOM and NWO.
- Large-Scale Facility for high resolution liquid NMR and Solid-State NMR Facility for advanced material science including an 850 MHz proton NMR instrument;
- Scanning Probe laboratory with a broad range of STM and AFM techniques (NanoLab);
- Life Science Trace Gas Exchange Facility;
- FLARE: Free Electron laser for Terahertz Experiments (operational 2011), and FELIX/FELICE: Free Electron Lasers for Infrared Experiments (2013). The foundation for Fundamental Research on Matter (FOM) and the Radboud University Nijmegen have agreed in 2010 to move two free electron lasers from Rijnhuizen to Nijmegen in 2012.

IMM has been successful in raising funds. More than 50% of the funding for the research staff is obtained from external research grants, contract research and so-called Public Private Partnerships (PPPs). In addition the research groups have been successful in acquiring funds for (large) investments in the Institute's research infrastructure, e.g.:

- Investment subsidy NWO Large for a wide-bore 850 MHz NMR spectrometer (M€ 4)
- Investment subsidy NWO Large for the Nijmegen Centre for Advanced Spectroscopy (M€ 25), including a new hybrid magnet for fields up to 45 Tesla and a Terahertz free electron laser (FLARE)
- Funding for the NanoLab from NanoNed (M€ 4)

The HFML has only 1000 hrs of magnet time per year, due to limited staff and resources. A research assessment in 2008 has recommended to raise the number of operation hours to at least 2000. For the HFML to run at full capacity (3000 hrs), an additional 3.5 M€ per year would be needed. As a first step in that direction, FOM and RU have joined forces by running the laboratory together. The support increased by 1.2 M€ per year, allowing an operation of up to 1600 hours. The additional funding required for full operation is actively sought.

Regarding human resources, the poor ratio of female and male staff is a point of attention of the IMM Board. The self-evaluation report points out that the fraction of female PhD students and

postdocs within the institute is much more favourable. Several tenure-track positions for talented young women with outstanding potential in the field of chemistry, physics, or astronomy have been advertised in 2010.

IMAPP

All IMAPP departments have been successful in attracting external funding. The self-evaluation report provides a list with the most notable grants. The HEP departments have been very successful in securing FOM programme funding. At the moment they participate in three FOM programmes:

- FOM Programme #7: Physics at the TeV scale: ATLAS
- FOM Programme #106: The origin of cosmic rays
- FOM Programme #104: Theoretical particle physics in the era of the LHC (TPP)

The self-evaluation report mentions that the research capacity of both the Theoretical HEP and the Experimental HEP is below the critical mass. IMAPP staff members suffer from a generally high teaching load.

DCN

With the start of the Donders Centre for Neuroscience, the university Board also provided additional funding to start the NeuroInformatics group (headed by Prof. Tiesinga, start July 2009).

The financing of the entire DCN (including the clinical departments; about 200 fte) consisted on average for 35% of direct funding (over 2004-2008; 45% in 2009), about 30% of research grants within the national and international competition, and about 35% of funding from contract research from industry and patient organizations (over 2004-2008; 27% in 2009).

In the past six years researchers from DCN received several prestigious grants including several from the VENI-VIDI-VICI scheme, EURYI, large investments grants and FP7 grants:

- FP7: Paediatric European Risperidone Studies PERS, 2009, J. Buitelaar (coordinator), M€ 5.6 in total
- FP7: Genetic and Epigenetic Networks in Cognitive Dysfunction GENCODYS, 2009, H. van Bokhoven (coordinator), M€ 11.8 in total
- FP7: Technological innovation of high throughput molecular diagnostics of clinically and molecularly heterogeneous genetic disorders TECHGENE, 2008, H. Scheffer (coordinator), M€ 3 in total
- FP7: Therapeutic and preventive impact of nutritional lipids on neuronal and cognitive performance in aging, Alzheimer's disease and vascular dementia LIPIDIET, 2008, A. Kiliaan, M€ 6 in total
- NWO Big: From Gene to Neural Function in ADHD, 2008, J. Buitelaar, M€ 1.3
- SmartMix: BrainGain Brain-Computer and Computer-Brain Interfaces, devices for measuring and modifying brain activity for healthy users and patients, 2007, P. Desain, M€ 24 in total
- EURYI: Mechanisms of neuronal interactions and their cognitive top-down control, 2006, P. Fries
- VICI grant: The three dimensions of aversive memories: neurons, hormones and genes (Theme 3), 2005, G. Fernández
- VICI grant: Sound processing in the primate brain: from neuron to cognition and behaviour (Theme 2), 2004, J. van Opstal

Assessment/remarks

The Committee fully agrees that the national and international position of the IMM is strengthened by the presence of a number of large-scale experimental research facilities. The track record of the institutes in fund raising and in acquiring prestigious grants is impressive.

4. Productivity

The results of the CWTS-analysis show that the Nijmegen programmes under review have produced 1183 articles in Web of Science journals in the 4 years of the review period. These articles were cited 20 010 times, not counting self-citations. The mean citation score is 2.42 for Physics of Molecules and Materials (IMM), 2.03 for High-Energy Physics (IMAPP), and 1.46 for Biophysics (DCN). The highest number of papers among the 10% most frequently cited papers is 2.42 for the IMM-group. The number of articles per full-time equivalent of academic staff ranges from 1.1 to 3.8 in the programmes under review. The average output per fte in all the programmes in this Physics review is 1.9.

Assessment/remarks

The productivity of the RU programmes under review was assessed as excellent for the IMM and IMAPP groups, and as good for the DCN group.

5. Societal Relevance

IMM

The self-evaluation report stresses that although IMM research is primarily curiosity driven, translation into marketable products is encouraged. The report provides a list with mostly chemical spin-off companies that have successfully been started in the past decade. The spin-off companies have generated some 800 jobs in the region. The Physics research groups were involved in ReRa Systems, SensorSense and tf2 devices.

IMAPP

An explicitly formulated part of the mission of IMAPP is to focus on a highly visible contribution to science outreach. Presentations on high-energy particle physics and astrophysics are given on many public occasions, e.g. in ScienceCafés or as guest lectures. The Mathematics departments have started a national mathematics competition. The Astronomy department organizes regular telescope observing occasions open to the general public.

DCN

The research on Perception, Action and Control has a direct link and impact to understanding the basic mechanisms of disease, exemplified by research on Parkinson's disease, research on (social) neuropsychiatric diseases such as attention deficit hyperactivity disorder (ADHD), impulse control diseases, and personality disorders, and research on autism. PAC research has paved the way to develop novel concepts for robotics applications and human-robot interactions that have been successfully implemented.

Within the research theme Brain Networks and Neuronal Communication, the work on Brain-Computer-Interfacing will improve future generations of neuroprostheses for various types of patients and has led to a number of patents and a spin-off company. Furthermore, transcranial stimulation techniques developed here can be used for therapeutic purposes such as pain management, movement disorders, and depression.

Improved understanding of the neural architecture, improved measurement techniques and data analysis methods, and understanding the genetic origin of brain morphology is expected to result

in better neuro-imaging methods and diagnostic tools for clinical diagnosis of psychiatric diseases, such as schizophrenia, autism and ADHD. Bayesian models of intelligent behaviour can be used to develop expert models with application in medical diagnostics or forensic science, which has formed the basis of spin-off companies.

Assessment/remarks

The societal quality, valorisation efforts and outreach activities of the institutes are well-managed and substantial. The societal relevance of the physics research was assessed as very good to excellent. The HiSPARC programme for secondary schools deserves a special compliment.

6. Strategy for the future

IMM aims to maintain and strengthen the viability and productivity of its research groups and wants to increase the visibility and output of its facilities.

The self-evaluation report mentions that the visibility of IMM for talented international postdocs has to be improved further. The institute needs an even stronger focus for maintaining competitiveness at an international level. Of highest priority are current initiatives such as the national Sector Plan (SNS), which offers the unique opportunity to appoint a number of talented (female) researchers and the planned integration of FELIX and FELICE (FOM Rijnhuizen) with the terahertz free-electron laser (FLARE) facility in Nijmegen, as well as increase the operation of the HFML. IMM will use the approved national Sector Plan for Physics and Chemistry (SNS) for further focusing the science within IMM on chemical biology and advanced spectroscopy. Funding is provided for two full professors and at least five assistant/associate professors.

The planned relocation of the free electron laser (FEL) facilities at the FOM Institute Rijnhuizen to Nijmegen in 2012 and combination with the terahertz free-electron laser (FLARE) and the HighField Magnet Laboratory (HFML) is a great opportunity for research on molecules and materials.

IMAPP

The overall strategy is to consolidate IMAPP's strengths in Astronomy and Mathematical Physics, to reinforce the efforts in Experimental and Theoretical High-Energy Physics, to improve considerably the quality and viability of the Algebra and Logic department and to build up a new research line in the direction of neuroscience for the Applied Stochastics department.

Scientific cooperation within IMAPP is strongly encouraged, building on the strengths in current collaborations especially in the realms of astroparticle physics and mathematical physics research. IMAPP seeks to complement the strong national embedding of its Astronomy and High-Energy Physics research by an equally strong national embedding of its mathematics research and to play a leading role in all its national collaborations with a view to a strong position in the relevant international research communities.

Establishing a coherent Master education programme is regarded as an opportunity for reinforcing the unity of IMAPP and further increasing its appeal to Master and PhD students.

Measures are being taken to limit the teaching load on IMAPP staff to reasonable proportions in comparison to the rest of the Faculty of Science.

DCN

In the coming years DCN aims to increase the activity and visibility of the Donders Institute in society and the research funding agencies. This strategy will include:

- strengthen the connections with industry and applied research centres.
- argue the case for cognitive neuroscience with government institutions and funding agencies.
- strengthen the animal research with new appointments.
- increase the public profile of the Donders Institute.

Assessment/remarks

The Committee fully endorses the strategic considerations of the institutes. Appropriate planning steps are being taken to ensure the continuity of the programmes.

Nijmegen has demonstrated with the High Field Magnet laboratory (HFML) that as a medium-sized university it can operate a large facility with great efficiency and at the international forefront. It will now become the home base of a set of advanced free-electron lasers ('FELIX'), which together with the HFML will create a unique set of research tools. It is of extreme importance that adequate baseline funding for the operation of these machines is in place.

The Committee heard that funding is available for FELIX to run 3000 hrs a year until 2023 and for HFML to run up to 1600 hours a year. The Committee regards this as essential for gaining good international visibility as an 'open-access' facility.

7. PhD Training

IMM

The education and training of the PhD students within the IMM consists of three components:

1. General academic skills, like presenting, writing, and research management,
2. Deepening of the knowledge via intensified courses, and
3. Broadening of the student's view on current scientific developments.

IMM's PhD education has a modular character: students select with their supervisors courses provided either by IMM itself or courses given in cooperation with other universities.

In collaboration with the Faculty of Science the training and guidance of the PhD students has been improved. An independent person now takes part in the go/no-go evaluation after approximately twelve months. Each following year another assessment of the progress is made.

The duration of the IMM PhD projects is approximately five years and six months. The institute finds this much longer than desired. The progress and duration of the PhD projects is an important topic in the annual evaluation of the research groups. In addition, IMM introduced a Rapid Graduation Bonus for PhD-students who submit their manuscript within the period of employment

The self-evaluation report notes that the annual 'sIMMposium', during which IMM PhD students and postdocs present posters and give oral contributions, stimulates interactions and joint projects between research groups. In addition, international top scientist are invited for the monthly IMM colloquium.

IMAPP

For the High-Energy Physics departments PhD education takes place within the context of three national research schools: OSAF (the Research School for Subatomic Physics) for all PhD students affiliated with the experimental programmes of Nikhef, DRSTP (the Dutch Research School of Theoretical Physics) for all PhD students in theoretical particle physics, and NOVA (Netherlands Research School for Astronomy) for PhD students with a mostly astrophysical

topic. OSAF, DRSTP and NOVA are KNAW-recognized research schools. OSAF was recently awarded an NWO Graduate School grant.

- OSAF has an extensive training and monitoring programme. It features three topical lecture series each year. The lecturers are internationally recognized leaders in their field. Each PhD student is required to attend at least six topical lectures. In addition, each PhD student is required to attend two two-week schools organized jointly by Belgian, Dutch, and German institutes.

The PhD student's progress is monitored by a C3 committee, consisting of thesis and daily supervisors and an external member of the OSAF board. The committee nominally meets four times over the course of the PhD student's employment. After 1 year, a "go/no-go" decision is made based on the PhD student's performance.

- The DRSTP features a similar requirement of attending two two-week schools. In addition, PhD students are expected to attend the annual DRSTP 'PhD Day', and to present a poster at the biannual 'Trends in Theory' conference. An external DRSTP board member verifies that the PhD thesis is of the requisite quality. Most PhD students falling under the DRSTP's purview are paid by FOM or Nikhef, and Nikhef steers the monitoring of their progress on an annual basis, similarly to the C3 committee.
- NOVA is the national top research school in astronomy, organizing many high level educational activities and also directly funding positions and equipment grants. The PhD student's progress is monitored by a NOVA education board member once a year, in addition to the normal meetings with the daily and thesis supervisor(s).

The self-evaluation report provides a table with the success rates of the IMAPP PhD students. The table shows that all students take longer than four years to complete their thesis.

DCN

All PhD students of the DI participate in the Donders Graduate School for Cognitive Neuroscience. This Graduate School was awarded a prestigious grant by NWO in 2009 as recognition for its excellent training programme, attitude for independent research and high level of MSc and PhD theses.

All students receive a Training and Supervision Plan (TSP) that is tailored to the student's needs, and is mutually agreed upon at the start of the PhD project. Students have to follow a series of dedicated courses (total of 18 EC, to be fulfilled within the first two years) and they are also expected to carry out a number of other academic activities (total of 12 EC), e.g. through attending seminars, inviting speakers, giving talks, preparing posters, etc. PhD students at FNWI are also involved in teaching activities, which take a total of 10% of the 4-year PhD contract time.

Apart from the daily supervisor(s), each PhD student is also assigned to a mentor, who is a Donders PI from a different group. The mentor acts as a general supervisor and confidentiality person, with whom the PhD student can discuss anything regarding the work. After 15 months the decision is made to either continue or discontinue the contract. The criterion for continuation is the reasonable expectation by supervisors and PhD student (based on past performance) that the PhD thesis will be ready by the end of the contract.

Each following year there will be an evaluation of the work, in which supervisors and mentor review a number of work-related issues with the PhD student. The result of the yearly evaluation

is a concrete plan of action for the next year.

From 2004 to 2009, 146 DCN researchers defended their PhD thesis. The main duration of the non-clinical PhD projects (54 in total) was about 5.5 years. To encourage students to finish the PhD project within 4 years, they earn a k€ 1.5 bonus if their manuscript is sent to the manuscript review committee before the end of their contract.

Assessment/remarks

The Committee finds the PhD training solid and effective. The PhD students are highly motivated and are satisfied with their training opportunities and supervision.

5B. PROGRAMME LEVEL - Radboud University Nijmegen

Programme RU 1: **Physics of Molecules and Materials**

Programme director: Prof. T.H.M. Rasing

Research staff 2009: 62.1 fte

Assessments:	Quality:	4.5
	Productivity:	5
	Relevance:	4.5
	Viability:	5

The objective of the group is to provide detailed experimental and theoretical insight and understanding in the relation between structure and properties of nanoscopic and molecular matter. The final goal is an increased understanding of molecules and materials from nanoscopic/molecular building blocks to complex functional materials. Regarding the key themes of IMM, the physics programme predominantly focuses on the following questions:

1. What are the fundamental properties of electron-correlated systems?
2. How does self-organization of complex systems work?
3. What are the fundamental properties of biomolecular systems?

Quality

The programme that comprises the physics activities in the Institute for Molecules and Materials (IMM) combines chemistry and physics, i.e. strong supramolecular chemistry, advanced spectroscopies and theory embedded in IMM with focus on correlated electron systems, self-organized systems, and biomolecular systems. Strongholds of the IMM are its advanced research facilities, such as the Nanolab, the high-field magnet laboratory (HFML), as well as NMR facilities and free-electron lasers in the microwave and infrared spectral range. The HFML is part of a network of leading European high-field laboratories, together with Dresden, Grenoble and Toulouse. The optical control of magnetism as evidenced by optically inducing a 100-fs magnetic-field pulse deserves special mention. Likewise, the very strong theory group has been instrumental in interpreting experiments of single-layer graphene, which was pioneered by the Nobel laureates A. Geim who is extraordinary professor of Radboud University, and K. Novoselov who obtained his PhD at Radboud University.

Productivity

The productivity of the programme is very high indeed, with a broad spectrum of activities and strong output in terms of publications in highly ranked international journals.

Relevance

The combination of the three foci of the IMM mentioned above is timely and apt to yield novel approaches to technologies. As a matter of fact, the industrial partnership on the colossal magnetocaloric effect and spin-offs on III-V solar cells with very high efficiencies have already demonstrated the relevance of the research for technology transfer.

Viability

The programme with its strong in-house research facilities is very well positioned to meet the challenges of the future. The accessibility of the in-house facilities such as the HFML and the future free-electron lasers to external users will add to the viability of the research along the lines of this programme.

Conclusion

The programme Physics of Molecules and Materials has fully demonstrated its competence in the past. With the strong in-house research exploiting the unique infrastructure at Radboud University, the prospects for internationally competitive research are very good.

Programme RU 2: **High Energy Physics**

Programme directors: Prof. N. de Groot, Prof. R.H.P. Kleiss

Research staff 2009: 13.5 fte

Assessments:	Quality:	5
	Productivity:	5
	Relevance:	5
	Viability:	5

This group carries out research into the origin and evolution of the universe. This is done in three sub programmes: experimental High-Energy Physics (HEP), theoretical particle physics and astroparticle physics.

The objective of the experimental work on collider based HEP is to investigate in particular the limits of our present understanding of particle physics as embodied by the Standard Model. In achieving this goal the group has focused a few key scientific questions (electroweak symmetry breaking, generation of mass, search for new particles). The group addresses these questions experimentally with the experiment D0 at the Tevatron in Chicago, USA, and with ATLAS at the Large Hadron Collider (LHC) at CERN, Geneva.

The theoretical HEP group studies fundamental problems in particle physics theory and plays a quite unique role in Dutch theoretical HEP by focusing mainly on a phenomenological approach. It plays a vital role by providing the theoretical basis for the analyses of the experimental data taken at the LHC and Tevatron.

The experimental research in astroparticle physics is to study the properties of Ultra High-Energy Cosmic Rays (UHECR) and their relation to astrophysical point sources, and to study the interaction of UHECRs with the Earth's atmosphere. The measurements are performed with the Pierre Auger experiment, located in Argentina, a large international collaboration.

Quality

The experimental HEP group plays a very visible role with significant impact in the experiments D0, and ATLAS, made possible both by the leadership role of the group members (e.g. by leading the successful Dutch engagement in the D0 experiment at Fermilab, USA), and their contributions to the hardware analyses in D0 and ATLAS. Like for all groups the close collaboration with NIKHEF is a major asset and enabling factor. The group addresses successfully some of the most central questions of the field of HEP and the quality of its contributions to experiments and publications are very high.

The group in theoretical particle physics has developed very powerful analytical and numerical techniques and has shifted its emphasis on techniques with considerable impact on ongoing analyses and the search for supersymmetry. Since 2005 the theory group is formally part of NIKHEF, its research is imbedded in a national strategy. This has intensified an already strong research in Quantum Field Theory.

In astroparticle physics the group has joined in 2005 the Pierre Auger experiment and implemented a new method to complement the existing methods for studying the properties of cosmic rays, namely the detection of radio emission which will provide information about the chemical composition. The theoretical basis and the first experimental proof of principle of this idea were pioneered by Heino Falcke of IMAPP and Peter Gorham. It was further developed by the KVI and IMAPP groups and it can now be implemented on a larger scale.

Productivity

The output and impact of the publications in the three sub programmes are very high. This is expected to even grow as the LHC and Pierre Auger are delivering more and more data.

Relevance

The focus of the research is on the understanding of the origin and the evolution of the universe and thus of high cultural relevance. In addition, the group has engaged in a remarkable way in bringing science into schools by initiating and running a science programme on cosmic ray extended air showers together with many Dutch high schools (HiSPARC). This enables high school students and teachers to participate in true front-line research.

Viability

While the D0 experiment is closing down in the near future, both the ATLAS and the Pierre Auger experiments will provide key insight in their respective fields for many years to come.

The recent very successful start of physics at the energy frontier with the LHC has opened up totally new possibilities for discoveries in particle physics. The group is well aware that the present funding for LHC by FOM will end in 2015, requiring a proposal for a continuation.

The group will be able to fill a new chair in theoretical physics and a new assistant professorship in experimental HEP from the sector plan.

Conclusion

The members of this programme have been very productive and internationally visible and will continue to be so by addressing highly topical questions of the origin and evolution of the universe, both experimentally and in their theoretical work.

Programme RU 3: **Biophysics**

Programme director: Prof. C.C.A.M. Gielen (-2010), Prof. A.J. Van Opstal (programme coordinator)

Research staff 2009: 23.6 fte

Assessments:	Quality:	4
	Productivity:	3.5
	Relevance:	4
	Viability:	3.5

The mission of the Biophysics group is to perform innovative, multidisciplinary and internationally competitive research into the functioning of the central nervous system by applying and developing novel theoretical concepts, advanced data analysis approaches, and experimental techniques and paradigms from physics and mathematics.

The theoretical component of the programme includes biophysical modelling of the non-linear subcellular mechanisms of nerve cells, of the phenomena that arise from interactions among small groups of nerve cells, of new phenomena, like coherent gamma oscillations, that emerge from large-scale networks of cells, to full cognitive systems that perceive and act.

The experimental approaches apply a wide range of behavioural and neuropsychological techniques to study normal brain functioning at different spatial-temporal scales that include single-cell recordings from nerve cells in behaving animals performing complex perceptual-motor tasks, functional magnetic resonance imaging in human subjects, diffusion tensor imaging techniques and electro- and magneto-encephalography in humans.

Quality

This evaluation only assesses the physics aspects of the interdisciplinary work embedded in the Donders Institute and thus may not appreciate all ramifications of the neuroscience research.

The scientific output of the physics programme was found to be internationally well recognized, but not yet at the leading edge of biomedical physics innovation. The various sub-groups seem largely unrelated, publishing to a large extent independently, with different scientific impact of their work. High impact publications have been produced, but while some have had a very significant scientific impact to date (for instance the 2007 Science paper by Pascal Fries and co-workers on the neuronal synchronization), others that were published in high impact physics journals such as PRL, have attracted hardly any citations. This is only partly explained by the fact that naturally the citations of the general theoretical models (e.g. for nonlinear stochastic systems) can never reach the same level as the experimental neuroscience publications.

Productivity

The productivity (output in relation to input) was judged to be good, but not outstanding, which is also supported by the bibliometric analysis. The Committee has taken the importance of conference proceedings into account, especially in the area of Machine Learning.

Relevance

Developing novel neuroimaging methods, e.g. diffusion weighted imaging for imaging nerve fibres, is extremely interesting and relevant. Moreover, modelling and simulation are indispensable in interdisciplinary areas such as the neurosciences. Pertinent underlying models, typically developed by physicists, are required to make the most of the accumulated data. Especially in view of the current pressure to avoid experiments involving animals (e.g. monkeys),

theoretical modelling is essential in order to extract as much information from the limited data-sets as possible.

Thus the physics programme embedded in the Donders Institute plays a central role. The impression was, however, that the translational impact from the general theory to the experimental neuroscience in the lab is not yet optimal, but could be improved by intensified interaction among the researchers among themselves and with other groups at the Institute.

Viability

The fact that P. Fries has left to join another institution in Germany is certainly a loss for the programme. However, measures have already been taken to fill this gap by hiring promising new staff and by extending the experimental work to novel two-photon cortical imaging techniques and optogenetics techniques through the appointment of two assistant professors.

Some other problems concerning the convergence of the physics and the biology approach are typical for interdisciplinary research of this kind, which is never straightforward and has its specific difficulties, since it involves researchers of very different scientific background. In the presentation some recent advancement in this respect was reported. An intention to focus more on particular themes was communicated, which makes much sense.

In general the Biophysics programme should be supported in its effort to reach more coherence and be strengthened by resources.

Conclusion

The physics programme embedded in the Donders Institute plays a central role that should be strengthened by all means. If the general theory and the experimental approaches could converge some more in the very unique and stimulating environment of the Donders Institute, the translational impact of the theoretical results could be sensational.

6A. INSTITUTE LEVEL - Eindhoven University of Technology

University: Eindhoven University of Technology
Faculty: Department of Applied Physics

1. The institute

The department has 11 research groups that are embedded in one of the three research clusters:

- Functional Materials
- Transport Physics
- Plasma Physics and Radiation Technology.

Collaborations within and between the clusters are actively stimulated. The budget allocation system contains strong incentives to maximise the output in research and teaching, and to obtain funding from governmental funding agencies and from industry. Both curiosity driven and applied research is performed, and 'valorisation' of the research results is stimulated. The department actively stimulates participation in large funding initiatives (Top Research Schools, DPI, NanoNed, CoE's, etc). These often include collaborations with external stakeholders.

Foresight Committees will review the mission of the clusters every 3-4 years in order to address new developments (e.g. when a chair holder retires and/or a new chair is created). The profiles for new chairs are formulated broadly, because the quality of the candidate is the prime criterion. Start-up financing is provided to enable rapid deployment.

There has been strong dynamism in each of the clusters: groups have been discontinued, new groups have been founded, groups have merged, a cross-departmental Platform Theoretical Physics² has been founded, groups have moved from one research cluster to another, etc. External factors like the emergence of the 3TU Centres of Excellence, TU/e Research Priorities, and institutes like the TU/e Energy Institute and the TU/e Health Institute have played and are still playing a role in these developments.

Most of the research within the department is embedded in National Research Schools, such as:

- J.M. Burgers Centre Research School for Fluid Dynamics
- Centre for Plasma Physics and Radiation Technology (CPS)
- Top Research School COBRA (Inter-University Research School on Communication Technologies Basic Research and Applications)³
- National Research Combination Photonics
- Research School Eindhoven Polymer Laboratories (EPL)
- Dutch Research School of Theoretical Physics (LOTN).

2. Quality and academic reputation

Staff members of the Department received 8 VICI, 5 VIDI and 4 VENI grants. The Department plays a prominent role in several Research Schools (Burgers, CPS, COBRA, EPL), in national initiatives such as Nanoned, Nanolab NL, Point One, M2I, and in large national projects such as

² All theoretical physicists in the department (about 20 % of the scientific personnel) are embedded in structures which also involve experimentalists. The Platform Theoretical Physics (PTP) plays a role in the teaching of several theoretical physics classes.

³ COBRA is a "Top Research School" by virtue of the NRC-Photonics research grant of 35 MEuro of the Netherlands government in 1998.

ADEM and HTS&M. Several members of the Department are members of the Editorial Boards of many professional physics journals and of several advisory councils. Very regularly, the department is organizer of professional conferences which are held in Eindhoven. The Department is (co-)organizer of several summer schools.

Assessment/remarks

The academic reputation of the physics institute is internationally very high. The appropriate balance of applied/innovative and basic/fundamental research will be an important aspect in maintaining this reputation.

All programmes scrutinized are well organized; the spirit is competitive but – as much as one can say from the outside – strain-free. Clear leadership is documented by on-time reforms, the abandoning of outdated topics, the implementation of new ones – often in interdisciplinary fields – the planning of the future, and the mostly impressive funding efforts and successes.

3. Resources

The Department's large cleanroom facility Nanolab@TU/e attracts researchers from all over the university, as well as from outside.

A large part of the ECN energy research centre will move to the Eindhoven region and the FOM Institute for Plasma Physics will be relocated to the TU/e campus. This will offer opportunities for shared infrastructure and is expected to strengthen the international position of the Department in the field of energy research. New or renovated buildings need to be realised.

The fraction of 2nd and 3rd category funding has substantially increased since 2004. The external funding exceeded the internal funding in 2006 and 2009. The external and internal funding now seem to stabilise at about equal levels. The department believes that this demonstrates the viability of the research. Too much dependence on external funding would make it impossible to maintain the present level of high quality academic staff. The current levels of funding are considered a good compromise.

The Department and the TUE have taken a range of measures to increase the number of female scientific staff. The aim is to be well under way in 2020 to the overall goal of 20 % females. In 2015 the percentage of female staff should be 10%. Promising female talents are scouted within the department's population of PhD students, but also in the national and international community. Subsidies from the Sector Plan Natuurkunde and the WISE programme (Women In Science Eindhoven) will enable individual groups to hire female scientific staff at 25 % of the cost for 5 years. After that they must generate their own income from the usual internal and external funding sources.

Assessment/remarks

As a consequence of the currently solid funding situation, all facilities – visited during the lab-tours - are excellent. Of high importance is the large clean-room which serves physics but also electrical engineering and is an installation of the whole university. It is essential that support and funding by the university of the clean room and its operation is continued.

4. Productivity

The results of the CWTS-analysis show that the Eindhoven programmes under review have produced 400 articles in Web of Science journals in the 4 years of the review period. These articles were cited 4034 times, not counting self-citations. The mean citation score is 12.51 for Functional Materials, 8.63 for Plasma and Radiation, and 6.83 for Transport Physics. The highest

number of papers among the 10% most frequently cited papers is 61 for the group Molecular Materials and Nanosystems. The number of articles per full-time equivalent of academic staff ranges from 3.5 to 1.2 in the subgroups of the TUE programmes under review.

Assessment/remarks

The productivity of the three clusters under review was assessed as very good to excellent.

5. Societal Relevance

Direct collaborations exist with large companies (Philips, NXP, Shell, OCE, ASML, FEI, DSM, NUON, AKZO-Nobel, Q-cells, Fujifilm, ASML) and smaller companies (Roth & Rau, Frencken, Innophysics). These collaborations involve both direct contract funding (e.g. PhD students paid by industry, working in the department) and sponsoring by the industry of project proposals to STW, FOM, DPI, CTMM, MZI, AgentschapNL, and EU. The aim is to produce good quality research results and publications in high impact journals. The knowledge intensive regional ecosystem (most of the above mentioned companies have their R&D headquarters in or around Eindhoven) fosters these collaborations.

An indication of the department's valorisation capabilities is the 2009 FOM valorisation grant awarded to Richard van de Sanden (Plasma and Materials Processing).

Assessment/remarks

The Eindhoven University is embedded within a high-tech area with other research institutions nearby and a well developed structure of large and middle-sized industry and enterprises. The Physics Institute fully makes use of this potential and has a high factor of valorisation of its scientific findings and achievements.

6. Strategy for the future

The Department aims at maintaining an influx of 100 students per year by attracting more students from outside Brabant and Limburg. Influx of students after their Bachelor degree from high level universities in China, Turkey and Russia is stimulated by active recruiting for the industrial scholarship programme.

The Department actively monitors internal and external scientific developments in order to be able to react to them adequately. The recommendations of the previous research review have all been followed up by well-considered actions.

Assessment/remarks

A specific comment addresses the cooperation options with the new fusion group at the TUE of Prof. Lopez-Cardozo. Plasmas are known to strongly rotate with a complex but highly interesting coupling of plasma turbulence and plasma rotation. Indeed, without this coupling, the confinement goals of fusion research, requiring low levels of turbulence, may not be reached. It would be a world-wide unique constellation if the two groups (WDY and the new fusion group) would pick up their earlier cooperation in these fields and carry out comparative studies on the relation between flow and turbulence. One can expect that the plasma in MAGNUM-PSI will rotate poloidally. This has, however, first to be demonstrated.

7. PhD Training

The number of PhD students has increased gradually over the years. The ratio of the number of PhD students and the number of tenured staff has increased from 4 to 5.5 in the years 2004 – 2009. This means that on average each tenured staff member is supervising more than 5 PhD students.

All PhD students of the department are trained in their discipline via summer schools and courses. They also follow a training programme that is tailored to each student, but contains a few fixed courses like Project Management, Technical Writing and Editing, Presentation Techniques, and a course on 'how to run your PhD project'. Almost all PhD students spend a 2 – 4 month period abroad, especially to experience a different research culture.

The success rate of the PhD students is high; virtually all PhD students obtain a PhD in the end, on average within 4.5 years.

Assessment/remarks

The physics institute has developed a high standard of PhD education. The groups have generally laid down their educational principles in clear procedures – a work plan with clear objectives at the beginning, the way and intensity of supervision, the definition of an accompanying educational programme including soft skills, the sending of students to summer schools and specialized workshops, the delegation to a research group abroad for a defined period, and the participation to international conferences with the expectation of active participation via a poster or talk.

6B. PROGRAMME LEVEL - Eindhoven University of Technology

Research cluster TUE 1: Functional Materials

Assessments:	Quality:	4.5
	Productivity:	5
	Relevance:	4.5
	Viability:	4.5

This Cluster is subdivided into the following five research programmes with an overall size of more than 75 fte in 2009:

- (1.1) Physics of Nanostructures (FNA), Prof. B. Koopmans, Prof. H.J.M. Swagten,
- (1.2) Photonics and Semiconductor Nanophysics (PSN), Prof. A. Fiore, Prof. P.M. Koenraad,
- (1.3) Molecular Materials and Nanosystems (M2N), Prof. R.A.J. Janssen,
- (1.4) Theory of Polymers and Soft matter (TPS), Prof. M.A.J. Michels, and
- (1.5) Molecular Biosensors for Medical Diagnostics (MBx), Prof. M.W.J. Prins.

The Committee notes that a common concern of all experimental groups in the Functional Materials Cluster is the future support of the central cleanroom facilities operated jointly by Physics and Electrical Engineering. Here continued support by TUE will be necessary to allow the groups to remain competitive on an international level.

In the following assessments of the programmes in this cluster, a separate grade is given to each programme which averages over all four assessment criteria. The scores for the cluster as a whole are a combination of the subprogramme assessments. No separate assessment texts are provided at the level of the cluster, in this case.

Programme TUE 1.1:	Physics of Nanostructures (FNA)
Programme director:	Prof. B. Koopmans, Prof. H.J.M. Swagten
Research staff 2009:	7.04 fte
Overall score:	4.5

The research aims at the exploration and exploitation of novel physical phenomena at the nanometer scale by manipulating the (spin-dependent) properties and structure of nanosystems. The work is curiosity driven, but with particular focus issues that are of potential relevance for the future development of (magnetic) data storage, information technology and other spintronic/nanoelectronic applications. Activities range from the design and production of nanostructures/devices, to the invention and application of advanced experimental schemes to gain fundamental understanding and explore routes for future technologies.

The scientists of FNA have produced a continuous high level of publications in top journals such as Nature, Phys. Rev. Lett. or Appl. Phys. Lett. They were able to attract two VICIs and other major research grants. Together with TPS and M2N they are among the world leaders in organic spintronics. As leading group in the field in the Netherlands they have accepted multiple responsibilities in coordinating national research programmes and are also very visible and active in the international spintronics scene. Although the number of PhD students has decreased somewhat towards the end of the assessment period, the viability of the group is considered excellent. In the future, more efforts should be devoted to the acquisition of EU funding and the

valorization of the research results via patents and development projects with industry. The overall score of FNA is 4.5.

Programme TUE 1.2:	Photonics and Semiconductor Nanophysics (PSN)
Programme directors:	Prof. A. Fiore, Prof. P.M. Koenraad
Research staff 2009:	23.03 fte
Overall score:	5

The ultimate goal of the group PSN is the full control of physical processes at the single charge-single photon-single spin level, and their application in future devices. They envision achieving this goal through epitaxial growth of ordered, atomically precise quantum dots, nanowires and impurity structures, combined with tuneable photonic bandgap microcavities, and the utilization of plasmonic effects in semiconductor-metal nanostructures. Their approach aims to push electronic, photonic and spintronic devices to the fundamental (quantum) limits regarding size, complexity, power consumption and speed. The research focuses on three key areas: novel nanomaterials, semiconductor nanophysics and single-photon physics.

PSN has grown impressively in the report period based on an outstanding success in acquiring research grants, including two VICIs for the group leaders. The scientific output of the group is entirely convincing both in terms of quantity and quality. In their specific field, they are leading nationally and certainly belong to the top five groups in the world. In addition to excellent science, the group has protected their IP by more than 20 patents and patent applications in the report period. They work closely together with industry in developing novel electronic and photonic structures for future devices. All in all, the viability and future prospects of the group are excellent. The overall score of PSN is 5.

Programme TUE 1.3:	Molecular Materials and Nanosystems (M2N)
Programme director:	Prof. R.A.J. Janssen
Research staff 2009:	25.34 fte
Overall score:	5

The research covers the chemistry, physics and materials science of functional nanostructured molecular, polymer and hybrid materials and nanosystems that may find application in photonic and electronic technologies. The programme combines synthetic chemistry with transient optical spectroscopy, advanced scanning probe microscopy techniques, and charge transport studies. The group has defined two thematic areas: (i) Molecular and Polymer Electronics (making new materials, exploring opportunities for improving existing and creating new applications such as light-emitting diodes, field-effect transistors, memories, power ratchets, sensors). (ii) Molecular and Polymer Photophysics (fundamental studies of energy and electron transfer reactions in molecular and hybrid systems, combined with the development of new materials and device architectures to provide new technologies for light emission, charge separation, energy conversion and storage).

M2N is quite similar to PSN in terms of size, successful funding and scientific excellence. The group has an excellent publication record with many high quality articles published in top journals, both in Physics and in Chemistry. The personal scientific impact and the international

reputation of the group leader Prof. Janssen is outstanding. M2N is well connected to small, medium and large companies. In particular the work on organic photovoltaics is of very high societal relevance. In comparison, the emphasis on patenting the most relevant research results has been quite small. The size of the group, the excellent available infrastructure and the dynamic development of organic electronics in R&D are convincing indicators for the future viability of the group. The overall score of M2N is 5.

Programme TUE 1.4:	Theory of Polymers and Soft matter (TPS)
Programme director:	Prof. M.A.J. Michels
Research staff 2009:	12.7 fte
Overall score:	4

This TPS group performs theoretical and computational physics research in the field of polymers and soft matter. They aim at understanding and predicting the triangle relation between (i) the structure at the molecular, nano- and mesoscopic scales, (ii) the dynamics of structure development, and (iii) the material properties of polymers and soft matter. Four themes are distinguished: Organic electronics and electro-optics, Computer simulation of multiscale dynamics, Self-assembly and structure formation in soft matter and biology, Function and soft mechanics of biomaterials.

The research done in this theory group is mainly relevant for the FNA, M2N and MBx groups in this cluster. One of the arguments for a separate theory group rather than theory embedded in the experimental groups was to maintain a separate identity and work together on theory. The Committee appreciates that much of the work is done in collaboration with the experimental groups, and that this is done in such a way that it does not hinder internal collaborations and synergies.

There are few faculty working on many different and distinct projects. There are at least three different subprogrammes identified. The group might consider to focus on one area of their own in which they can establish clear leadership while pursuing their extensive collaborations in addition. The scientific quality and the output of the group is very good, but has not yet reached the same level of international leadership as for the experimental groups. Also the societal relevance of the work is somewhat less obvious. Based on the continuous growth in the past and the successful acquisition of external funding the viability of the group is judged between very good and excellent, with the caveat of a better research focus mentioned above. The overall score of TPS is 4.

Programme TUE 1.5:	Molecular Biosensors for Medical Diagnostics (MBx)
Programme director:	Prof. M.W.J. Prins
Research staff 2009:	7.67 fte
Overall score:	4

MBx investigates nanotechnologies for biophysical studies which have application potential in integrated medical biosensors. Their objective is to develop experimental bio-nanotechnological concepts and to support these by physical model descriptions, in order to lay scientific foundations for novel generations of integrated lab-on-a-chip medical biosensors. This field

combines micro- and nano-technology and physical sciences on the one hand, with molecular biology and bioengineering on the other. The group develops bionano technologies based on particles and integration, and uses these for investigations on proteins, cells and nucleic acids. The use of particles allows them to capture and actively transport biological materials, to control and detect the formation of biomolecular bonds, and to quantify the properties of molecules and cells in samples of complex biochemical composition.

MBx is the youngest and smallest group in the Functional Materials Cluster and was established in the course of the assessment period. Between 2005 and 2009, it has grown to a similar size as the established FNA group, but the scientific productivity naturally has not yet reached the same level of productivity and international recognition. The project leader Prof. Prins only has a part time appointment with TUE and is a Research Fellow at Philips. Apparently, this situation has worked out quite well and is helpful for the valorisation of the biosensors developed in MBx. The societal relevance of the work is potentially very high, and the intellectual property of the group has been secured by numerous patents and patent applications. Given the past performance and current funding situation, the future viability of the group has been perceived as very good. The overall score of MBx is 4.

Research cluster TUE 2: Plasma Physics and Radiation Technology

Assessments:	Quality:	4
	Productivity:	4.5
	Relevance:	4.5
	Viability:	4.5

This Cluster comprises the following 3 programmes:

(2.1) Coherence and Quantum Technology (CQT) of Prof. K.A.H. van Leeuwen,

(2.2) Elementary Processes in Gas Discharges (EPG) of Prof. G.W.M. Kroesen,

(2.3) Plasma and Material Processing (PMP) of Prof. M.C.M. van de Sanden.

In the following assessments of the programmes in this cluster, a separate grade is given to each programme which averages over all four assessment criteria. The scores for the cluster as a whole are a combination of the subprogramme assessments. No separate assessment texts are provided at the level of the cluster, in this case.

Programme TUE 2.1:	Coherence and Quantum Technology (CQT)
Programme director:	Prof. K.A.H. van Leeuwen
Research staff 2009:	13.14 fte
Overall score:	4.5

The work of this group focuses on collective effects in dilute, strongly interacting systems of high phase-space-density: ultra-cold atoms, quantum gases and plasmas, high-brightness electron, ion and atom beams. These fields are modern and attractive with an excellent potential for the future. In terms of applications the group aims at developing new sources of charged particles and radiation. These find wide applications in medicine, industry, and science.

The group was formed from a merger of two older groups and the recognition of the common physics and methodologies opening a field with far-reaching potential. The CQT is structured into 4 subprogrammes with 6 Principal Investigators. The research field of the group conforms fully to the “Sectorplan Natuur- en Scheikunde” and falls into two focus areas. The group is well structured and organised. It cooperates intensively with the other programmes of the Cluster. There is a strong interaction with other groups within the department and within the TUE with Chemistry and with Electrical Engineering. The main national cooperation partners are experimental groups in UvA, VU and UU. The group is integrated into strong international cooperation with groups in USA, Australia, Israel, Germany, France, Austria, UK and other countries. The group was impressively successful in acquiring funding from national and external sources. In most of the cases the funding via one VICI award and several FOM and STW grants go beyond 2009.

The technical and support infrastructure of the group is excellent.

The bibliographic data demonstrate the excellent scientific work of the group. Naturally, the merger caused a reduction of the publication activity, but the new research fields are rich enough so that the publication figures are expected to be back. The group concentrates on high-quality publications, which has to be applauded, with about 10% of them being published in PRL.

The number of PhD students decreased as a consequence of re-structuring, but increased again in 2009.

The CQT has a tradition in technology transfer specifically in the field of accelerator equipment. Another branch of industry cooperation is electron and ion beam instrumentation. These areas also have a high societal relevance in health and life sciences. Therefore, it is highly probable that 2nd-tier and 3rd-tier funding will further increase. The group had one patent in 2009.

All four subprogrammes have an excellent strategy and a clear vision of the future. The CQT intends to further focus its scope which is encouraged by the evaluation panel. The need of more post-docs is stressed which might partly be met by intensifying the PhD programme. Facing the general need to increase the number of physics freshmen, the participation in outreach programmes is necessary; some of the programmes of CQT have the potential to interest the public.

The overall grade for CQT is 4.5 (between very good and excellent).

Programme TUE 2.2:	Elementary Processes in Gas Discharges (EPG)
Programme director:	Prof. G.W.M. Kroesen
Research staff 2009:	13.76 fte
Overall score:	4

The programme of this group covers the field of low-temperature/applied plasmas with focus on elementary plasma processes and on the interaction of the plasma with its material limitations. The objectives of the group are exploring the fundamentals of low-temperature plasmas as a basis for novel applications with environmental and medical relevance. The scope of the group includes experiments, the development of novel techniques for plasma diagnostics, theory and modelling representing a complete and coherent approach, which is – internationally seen – a unique selling point.

The group is guided by 8 Programme Leaders. The members of the EPG have a high international reputation. They occupy visiting professorships, serve as advisors, received prizes or – in case of younger members – have an impressive record in best paper/most cited paper awards. The EPG is well structured and managed. Because of their interdisciplinary approach, the group can participate in three topics of the already mentioned Sectorplan. The EPG cooperates with other groups within the Applied Physics department (Fusion, CQT and WDY) and with groups of other departments (Chemistry, Electrical-, Chemical, and Biomedical Engineering).

Group members are recipients of two VENI and two VIDI awards. In addition, the group is very active in acquiring funding from national agencies (STW, FOM, NWO and others), from outside the Netherlands, and from industry. In the average, less than 1/3 of the EPG budget originates from institutional funds.

The group enjoys excellent technical infrastructure.

The scientific work of the EPG has a high quality and a high significance for the practical application of the results and the transfer of know-how to industry. The relevance of the work is demonstrated by patents (6 in the reporting period) and a high number of publications. The formal bibliometric success indicators are, however, average. This is typical for small and interdisciplinary fields located between basic research and applications.

The group has a high number of PhD students with about four students finishing per year.

Some of the research goals of the EPG have obvious environmental benefits. In order to valorise products and techniques, EPG has developed an extended network with industry in the fields of lighting, lithography, medical applications, and solar cells. In total, the network consists of about 12 companies. The research fields of the EPG – centred on the core research areas energy, environment and health – experience internationally a tremendous boost of recognition and appreciation, which affects also funding from all major agencies. All the necessary pre-requisites seem to be at hand to ensure further success of this group.

The group might consider strengthening the basic aspects of its research. This is challenging but possibly rewarding also in areas like the use of plasma techniques for medical purposes –an exciting new field.

The overall grade for EPG is 4.0 (very good). In assessing the quality of the work, the academic level of the scientific output has been considered. Following the recommendation above and possibly intensifying international cooperation, eventually also the bibliometric indices might improve.

Programme TUE 2.3:	Plasma and Materials Processing (PMP)
Programme director:	Prof. M.C.M. van de Sanden
Research staff 2009:	27,53 fte
Overall score:	4.5

The objective of the PMP group is to get an understanding of plasma-surface interactions during plasma-based processing of materials at the atomic level through the use of state of the art in situ real-time diagnostics. Potential application fields are nano-manufacturing, energy technologies and sustainable processing of materials. Within the group four lines of research have been developed:

- High throughput processing;
- thin-film nano-manufacturing;
- plasma-polymer interaction and interface formation;
- plasma-surface interaction and molecule formation.

The group is guided by six Programme Leaders with outstanding international reputation evidenced by many prestigious prizes, fellowships, visiting professorships and other distinctions. The research field is connected to two focus areas of the Sectorplan. The PMP is well linked to the other two groups of the Cluster. Within the department, it cooperates with the PSN and FNA groups on plasma diagnostics and material processing. At the university level, cooperations are established with Chemical and Electrical Engineering. At the national level, there exists a network of collaborations with universities and research institutions. Internationally, the PMP cooperates intensively with European, specifically German groups but also with teams in Japan, China, and USA. The group has an outstanding funding record with a continuous growth over the years. In 2009, the funding from contracts surpassed the public funding by about a factor of 2. A sizable fraction of funding originates from royalties. The group also enjoys one VIDI and one VICI award.

The technical infrastructure of the group is very good; more technical support is necessary, however.

The group has a worldwide recognized leadership position in the area of plasma-assisted atomic layer deposition which gave rise to a breakthrough in the production of high-quality photovoltaic panels (passivation, oxidation, anti-reflection coatings). The output of refereed papers is high with a steady increase. Most impressive is the number of patents. In the reporting period, 37 patents were registered, which seems to be a record in Dutch physics.

The PMP has a high throughput of PhD students. It is remarkable that many of them receive awards and recognition already in this early phase of their career – the valorisation prize of the Leverhulme Trust, the Junior Einstein Award, and for master students - two Shell Master Prizes and a Casimir fellowship for a post-doc.

From what is said above, it is clear that the work of the PMP group has high societal relevance specifically for the field of renewable energies. Also the value of valorisation is of the highest level and borne out by the FOM Valorisation prize granted to Prof. van de Sanden. The structural changes with the move of the FOM institute DIFFER, the Eindhoven Energy Institute, and the EIT KIC InnoEnergy programme will open the door to also consider plasma assisted fuel production techniques. An interesting field could be the area of plasma-assisted catalysis. Many of the funds started recently and continue into the next years.

The overall grade for PMP is 4.5 (between very good and excellent).

Research cluster TUE 3: Transport Physics

Assessments:	Quality:	4
	Productivity:	4
	Relevance:	4
	Viability:	4

The TUE group on transport physics is a vital group with a broad range of interests from the fundamental physics of turbulence, to high and low Reynolds number flow, to heat and mass transport and their engineering applications, to practical problems such as coatings, and degradation of porous material, to problems relating physics and biology in the population dynamics of hydrodynamically driven systems. The emphasis of the group is on multiscale phenomena both in the overlap of the different subfields and in individual projects.

The TUE Transport group participates with the other major hydrodynamics groups in the Burger's Centre, a well-run national effort that helps coordinate research and runs courses, workshops and seminars. Students at TUE feel that this is a very effective way to give them a broad education by experts in all areas of fluid dynamics.

There have been substantial changes in this group over the period 2004-2009. With the retirement of De Waele the low temperature group has appropriately been discontinued. Similarly the Gas Dynamics programme of Van Dongen has morphed into Mesoscopic Fluid Dynamics. The additions of Darhuber and Toschi added new strengths in microfluidics and multiphase flows.

Quality

The overall quality of the research is high, nationally leading and internationally competitive in their areas of expertise.

Productivity

There have been and continue to be substantial changes in the faculty associated with these three subprogrammes and as such there is a great deal of yearly fluctuations in the number of PhD students and the publications output. The exception is the turbulence subgroup which has maintained a fairly steady and high student and publication record. There is also a large variation in citations between the subgroups. The MTP has a substantial number of high profile publications and is well cited. The Permeable Media group is less well cited possibly due to its relevance to a field more commonly associated with civil, chemical and mechanical engineering departments.

Relevance

Aside from the educational and scientific training of PhDs associated with this programme there are many societal aspects in these studies including environmental topics in relation to laminar and turbulent flows with droplets or aerosols (volcanic dust; rain formation; oil spills; formation of algae blooms; radioactive aerosols). There is strong overlap with industry in terms of coatings, the development of fluidic sensors and oil recovery. The work of the TPM group on the degradation and hardening of construction materials (concrete, cement, bricks) and car paints as well as the preservation of cultural heritage obviously has a very high economic and societal relevance.

Viability

The turbulence group is well established and well funded. The recent addition of young faculty

has strengthened the mesoscopic group. Particularly in the case of Prof. Toschi, whose interests and activities span both groups, as well as in Mathematics, efforts should be made to strengthen resources and support. The upcoming retirement of Kopinga threatens the viability of the TMP group, which will require a new scientific leadership and a certain reorientation of research directions towards more physics-oriented topics, as well as a better integration into the Transport Physics Cluster.

The assessments of the programmes in the cluster Transport Physics are as follows.

Programme TUE 3.1:	Mesoscopic Transport Phenomena (MTP)
Programme directors:	Prof. A.A. Darhuber, Prof. M.E.H. van Dongen, Prof. F. Toschi
Research staff 2009:	11.7 fte
Overall score:	4.5

In the period 2004-09 four lines of research coexisted in MTP:

- 1) research on condensation phenomena and aero-acoustics (Hirschberg);
- 2) fluid dynamics at small length scales (Darhuber, Harting);
- 3) multi-scale systems and the interplay of turbulent flows with small-scale phenomena (Toschi, Harting);
- 4) research on thermoacoustics (Zeegers).

The present and future specialization of MTP is micro-, nano- and meso-scale fluid dynamics. One central topic of interest is structure and pattern generation within liquids or utilizing liquids. Another focus is on multi-scale phenomena, where the interplay of effects occurring at disparate length scales governs the overall system dynamics. Examples include the evolution of plankton populations in the sea or of soot pollutants in turbulent combustion.

This young group does experiments and simulations/ computations on nano to micro scale multiphase flows. There is strong overlap with soft matter physics in the role played by surfactants and Marangoni effects. The group went through a dip in the number of students but is rebounding. There is substantial external funding through competitive grants and industrial contracts. Implications for practical problems from blood flow to enhanced oil recovery are under investigation. Particularly impressive is the amount of supercomputing time, 120 million Blue Gene processor hours, granted to this group.

The group has 1 VICI (Darhuber) and 1 VIDI grant (Harting).

Programme TUE 3.2:	Turbulence and Vortex Dynamics (WDY)
Programme directors:	Prof. H.J.H. Clercx, Prof. G.J.F. van Heijst, Prof. F. Toschi
Research staff 2009:	12.16 fte
Overall score:	4.5

The primary objective is to gain insight in fundamental aspects of heat and mass transport in vortex flows and turbulence, and its dynamical feedback on the flow, on scales varying from microns to thousands of kilometres. The research topics are motivated by geophysical and environmental phenomena, and by mixing processes in a few selected industrial applications. Topics that are studied include: turbulence and vortices in rotating and stratified fluids, two-dimensional turbulence, turbulence in geophysical systems, particles and droplets (with phase

transitions) in turbulent flows, and chaotic mixing in viscous fluids. The attention is focussed on transport properties (and small-scale dynamics) of these types of flows.

This group couples well with MTP partly due to the presence of Toschi in both. The group is growing in number of students as well as faculty with two new lines in 2010-2011. There has been a substantial number of high-level publications. They deal with aspects of heat and mass transport, over scales from 1e-6 to 1e6 meters, in vortex and turbulent flows. There are experiments as well as modelling efforts. The strategy is that on the basis of fundamental studies, geophysical and environmental topics can be tackled. Industrial applications in the field of fluid mixing with emphasis on laminar processes are treated as well. The complexity of the turbulence studies result from the non-linearities in the processes and the need to cover many scales because small-scale processes affect the macroscopic transport on large scales. Turbulence is studied for effects ranging from geophysical flows to "Life at High Reynolds Number".

The members of the WDY group have an outstanding international reputation and they are well equipped for their studies with a wind tunnel facility; water channel facility; rotating table facility; turbulence chamber; modern flow visualization diagnostics and data acquisition systems.

The group has 1 VICI (Clercx) and 1 VIDI grant (Van de Wiel, Boersma).

Programme TUE 3.3:	Transport in Permeable Media (TPM)
Programme directors:	Prof. K. Kopinga, Prof. O.C.G. Adan, Prof. P.F.F. Wijn
Research staff 2009:	8.06 fte
Overall score:	3.5

The group investigates the transport in permeable media and its effect on processes that determine the integrity of materials (deterioration). These processes are studied on a multi-scale level. Applications are found in civil engineering, the conservation of cultural heritage, petro physics, chemical engineering, and medical engineering. Focus is on:

- a. porous materials of macroscopic dimensions: rocks, bricks, and concrete
- b. micron-sized layers on porous materials: coatings and (bio)films.

The focus of this group is on application-driven research from automotive coatings to preservation of concrete structures. They have developed worldwide unique apparatuses and techniques for the imaging of thin films by high resolution NMR which can detect e.g. variations in water content over micron scale distances. However, the review panel noted a certain lack of physics oriented research.

The number of publications as well as the number of completed PhD theses has been declining towards the second half of the assessment period, partly due to the duties of Prof. Kopinga as Dean. Since 2007 the number of PhD students is steadily increasing again, thanks to considerable success of the group in securing funding from STW, TNO and the EU

The bibliometric analysis of the scientific output of this group shows a comparatively low citation frequency, which was partly explained by the fact that publications of the group in the very specialised literature dealing with construction materials are not referred to in the physics literature.

The viability of the group will strongly depend on how the imminent retirement of Prof. Kopinga in two years will be dealt with. A tenure track appointment as a replacement is currently sought. This should also be used to achieve a better embedding of the TPM group in the Transport Physics Cluster.

7A. INSTITUTE LEVEL - University of Amsterdam

University: University of Amsterdam
Faculty: Faculty of Science (FNWI)

1. The institute

The mission of the Institute of Physics at the University of Amsterdam (IoP-UvA) is to carry out excellent research in the field of experimental and theoretical physics, to provide inspiring teaching within the physics and other curricula and to transfer their knowledge and enthusiasm into society, both in the form of collaboration with industrial partners as well as in terms of boosting interest in physics in general and in its study in particular.

The IoP comprises three research divisions, which in the period up to 2010 were independent research institutes within the Faculty of Science (FNWI) of the UvA:

- the Van der Waals Zeeman Institute for Experimental Physics (WZI), director: Prof. M.S. Golden
- the Institute for Theoretical Physics Amsterdam (ITFA), director: Prof. K. Schoutens
- the Institute for High Energy Physics (IHEF), director: Prof. S. Bentvelsen.

From January 1st 2011 these three formally united into a single IoP-UvA. The constituent divisions maintain their independent position in their respective fields of expertise, but work together in matters that concern all of Physics at the UvA. The IoP is led by a board consisting of the three division leaders. Since the summer of 2010, ITFA and WZI are housed in the new FNWI building in Science Park Amsterdam. IHEF is in the Nikhef building, on the other side of the road.

Spearhead discussions in the FNWI and nationally in the context of the Sectorplan have led to a sharply defined research and investment agenda, which is coordinated with the research at the VU and nationwide. The IoP research has the following focus areas:

- Astroparticle Physics and Gravitation (programmes UvA 4 and 6)
- Quantum Matter and Quantum Information (programmes UvA 1, 3 and 5)
- Complex Systems, Liquids and Matter (programme UvA 2 and 5).

The IoP's research themes are strongly tied to the three leading tracks in the MSc Physics degree programme: Particle and Astro-Particle Physics, Theoretical Physics and Advanced Energy and Matter Physics (AMEP).

The ITFA also maintains a programme on the History of Physics (Prof. A.J. Kox), which is not included in the 2011 research evaluation.

The particle and astroparticle physics programme at IHEF is fully integrated in Nikhef, the National Institute for Subatomic Physics. The integration is both scientific and financial, which makes it somewhat arbitrary to distinguish between the contributions of IHEF and Nikhef. The partnership Nikhef constitutes FOM with four universities (Nijmegen, Utrecht, Amsterdam UvA and Amsterdam VU).

Assessment/remarks

The move to the new building and locations seems to be quite successfully fostering more communication and collaboration between the different faculty members, students and groups.

The university should continue to recognise and actively support the symbiotic relationship between the Particle Physics groups (UvA 4 and 6) and Nikhef.

2. Quality and academic reputation

The self-assessment report gives an extensive list of high-profile publications, major research grants, programmes with IoP leadership or participation, prizes, awards, editorships and memberships. These elements are taken into account in the programme assessments.

The following personal grants are mentioned:

- Spinoza prize R.H. Dijkgraaf (2003). Volume M€ 1.5.
- Spinoza prize E. Verlinde (2011).
- ERC Advanced Grant E. Verlinde (2010). Volume M€ 2.0.
- VICI grants (ca. M€ 1.3 each): S. Bentvelsen (2006), K. Skenderis (2008), P. de Jong (2009), J.-S. Caux (2010)
- VIDI grants (ca. k€ 630 each): N. J. van Druten (2002-2007), K.E. Schalm (2005), M.M. Taylor (2005), A.P. Colijn (2005), P. Schall (2006), I. van Vulpen (2006), C. Castelnovo (2010)
- FOM Springplank fellowship J.-S. Caux (2003-2007). Volume ca. k€ 200.
- Vernieuwingsimpuls (oude stijl) K. Skenderis (2002-2007). Volume k€ 448.

Assessment/remarks

The quality of the UvA programmes under review was assessed as very good to excellent.

3. Resources

The self-assessment report states that the IoP has a clear and healthy financial medium-term future, in terms of direct funding, based on its excellent performance, proactive role in instigating attractive spearhead proposals and sound financial governance over the last 6 years. This is expected to provide the basis for continuation and extension of its success in attracting external funding. The spread of themes from fundamental (quantum universe/quantum matter themes) through to applied (soft condensed matter and energy) also means the IoP is able to make use of the full breadth of funding possibilities.

The facilities and infrastructure feature a new 'single-site' building, enabling interaction with related disciplines (astronomy, maths, chemistry). The strategic location in the Science Park Amsterdam also stimulates links with national institutes (Nikhef, CWI, AMOLF).

The FNWI MacGillavry programme, together with gender specific measures offered by the SNS-sectorplan, offers opportunities for attracting female staff members.

Assessment/remarks

The new lab facilities are very good and in some cases a significant improvement over the previous labs.

The FNWI MacGillavry programme is dedicated to increasing the number of women in the faculty. Such efforts are highly commendable.

4. Productivity

The results of the CWTS-analysis show that the UvA programmes under review have produced 1241 articles in Web of Science journals in the 4 years of the review period. These articles were cited 14181 times, not counting self-citations. The mean citation score is 5.25 for Hard

Condensed Matter, 11.7 for Soft Condensed Matter, 29.52 for Quantum Gases and Quantum Information, 11.2 for Particle Physics, Cosmology and Quantum Gravity, 8.16 for Quantum Matter and Complex Systems, and 11.63 for Particle and Astroparticle Physics. The highest number of papers among the 10% most frequently cited papers is 79 for Particle and Astroparticle Physics. The number of articles per full-time equivalent of academic staff ranges from 0.8 to 5.4 in the UvA programmes under review, with an average of 2.5. The average output per fte in all the programmes in this Physics review is 1.9.

Assessment/remarks

The productivity of the UvA programmes under review was assessed as very good to excellent, with the exception of the programme Quantum Gases & Quantum Information, which was assessed as good.

5. Societal Relevance

The self-assessment report lists an impressive array of activities that are aimed at contributing to the awareness and appreciation in society of the natural sciences and of physics in particular. These include media productions, public lessons, books, events at the NEMO science museum, outreach to teachers and even theatre plays and movies. Just one example is the 'betacanon', which received important contributions from Bais, Dijkgraaf and from a number of Physics PhD students at the UvA.

Valorisation activities include joint research or industrial partnerships with Shell, DPI, Unilever, ECN, Michelin, ASML and SKF. Successful transfer of lab technology was realised to the aviation industry (ultrasonic verification alarm) and to SPECS Nanotechnology Delft (UHV-cryomanipulator) with several partners.

Assessment/remarks

The Committee found the outreach efforts and the valorisation activities very well-defined and successful.

6. Strategy for the future

The IoP is currently major player in three research initiatives within the FNWI:

- *Gravity and Astroparticle Physics* (GRAPPA)
- *Quantum Matter and Quantum Information* (QM/QI) and
- *Soft Matter*.

The GRAPPA centre has already been granted the status of a UvA Centre of Excellence, and as such it receives generous financial support from the FNWI and UvA's CvB. GRAPPA is an initiative going beyond the bounds of the IoP. It includes a group from the UvA Anton Pannekoek Institute (API) for astronomy and clearly benefits from the proximity of Nikhef and of the international particle physics consortia, especially at CERN, that the Nikhef is part of. The GRAPPA theme is increasingly important in the MSc education: GRAPPA 'study-paths' will be on offer in a number of tracks within the MSc programmes 'Physics' and 'Astronomy'.

The IoP is also playing a key role in the synthesis of a new spearhead proposal: Quantum Matter / Quantum Information. This involves theory (programme UvA 5) and experimental (programmes UvA 3 and 1) groups within IoP, together with groups at the Centre for Mathematics and Informatics (CWI) in the Science Park. Members of the Quantum Geometry group from the maths institute in the FNWI are also expressing an interest in affiliating to the QM/QI initiative. This spearhead involves research into quantum information as can be realised

in novel quantum gas and topological insulator systems, coupled to theoretical expertise as regards entanglement theory and the physics of topological states. QM/QI maps perfectly onto the SNS-sectorplan national spearhead of the same name centred on the UvA physics institute.

A third spearhead *in spe* is Soft Matter, bringing together experimentalists (programme UvA 2) and theoreticians (programme UvA 5) from IoP, with computational and experimental scientists from the chemistry institute HIMS and from AMOLF.

Finally, Amsterdam is a fertile environment for the energy-related research of the experimentalists (programme UvA 1), with the VU, UvA chemistry and AMOLF as important and visible partners.

Assessment/remarks

The Committee fully supports the well-defined strategic direction and focus. They seem to provide a good basis for a number of succession decisions that will have to be taken in the near future.

7. PhD Training

Each of the three IoP divisions (ITFA, WZI, IHEF) has their own channels for PhD education. ITFA's main channel is via the Dutch Research School for Theoretical Physics (DRSTP). WZI uses PhD schools organised by InterCan and by large scale facilities (Hercules, PSI schools, etc.). IHEF's PhD training takes place within the national research school on subatomic physics (OSAF).

About 80% of the PhD students within IoP are either FOM employees and about 20% are employed by UvA. Both organisations have an established system of training & supervisory plans and annual progress reviews. FOM PhD employees have access to transferrable skills training (Dutch, time management & planning, career orientation) and the best practices built up by FOM over the years are a good inspiration for the UvA as employer of the NWO/EU funded PhD's which fall under her HRM remit.

Overall, some 18% of the PhD students finish within 4 years, while 62% obtain their PhD within 5 years. Only 4 out of 77 PhD projects have been discontinued.

In the coming period, the Amsterdam Graduate School of Science (AGSS) - which is a joint venture with the VU - should begin to take shape. This is expected to provide a good basis for high-quality transferrable skills training, careers guidance and quality control, complementary to the activities of the national research schools.

Assessment/remarks

PhD-students are very satisfied with their overall situation at UvA, however there were complaints about the - apparently, for students - very limited service and access possibilities for personal laptops. Terminal pools are space consuming, possibly inconvenient and seemingly outdated.

Soft Matter (UvA 2) organizes national meetings every few months and hosts a national website. Condensed Matter (UvA 1, 3, 5) and High Energy Theory (UvA 4, 6) also have lively traditions of national meetings. The PhD council of the Dutch Research School for Theoretical Physics organizes an annual PhD-day. Such efforts should be encouraged and supported.

7B. PROGRAMME LEVEL - University of Amsterdam

Programme UvA 1: **Hard Condensed Matter**

Programme director: Prof. M.S. Golden

Research staff 2009: 10 fte

Assessments:	Quality:	4
	Productivity:	4
	Relevance:	4
	Viability:	4.5

The programme concentrates on the electronic and optoelectronic properties of novel solid systems and has two research lines: quantum electron matter (QEM) and optoelectronic / nanophotonic materials. QEM studies the fundamental properties of correlated electron materials. Research highlights are new ferromagnetic superconductors as well as the systematic electronic structure characterisation of iron pnictide and conventional high T_c superconductors with advanced spectroscopic methods in real space and in reciprocal space. In the semiconductor-related work, silicon-based and other quantum dot systems are used to tune and manipulate optical and optoelectronic properties for fundamental photovoltaic energy research.

Quality

This group is among the leaders in the Netherlands in its specific field of research, and is well known, often invited to or active in organizing international conferences, but in the period under review not yet leading internationally. The group members have published a good number of outstanding publications in the best journals of the field (Nature, Phys. Rev. Lett.) and pursue the laudable policy of trying to produce fewer but better publications.

Productivity

The productivity of the programme in terms of papers is very high, but continuously decreasing since 2004. Part of this is probably due to the mentioned “postdoc gap” from 2006 – 2008, which has not been explained but taken care of in the meantime. The ability to attract external funding is sufficient to maintain the current level of research activities, but lacks highlights which would be visible beyond the Dutch borders and would allow the group to make a major step forward in terms of equipment and/or personnel.

Relevance

The group has contributed appropriately to University and national outreach, educational and recruiting activities. Several promising contacts with local or European industry exist for the industrial valorisation of some of the fundamental research results. The university’s Knowledge Transfer Office (BKT) is involved in most cases and the group has a clear IP strategy. The photovoltaics-related research has general relevance for the future energy programmes in the Netherlands and in Europe.

Viability

The research topics covered in this programme remain at the forefront of research in hard condensed matter and, thus, can count on many more years of basic research to be funded. The group has made a lot of postdoc appointments in the recent past and, thus, is well positioned for the near future. An important issue remains the succession of Prof. Gregorkiewicz, which is currently discussed in the faculty. Here, an important decision has to be made between a further concentration of the research activities in this programme or trying to maintain a fairly broad

activity spanning metals, semiconductors and dielectrics. The recommendation of the review panel is in favour of the latter.

Programme UvA 2: **Soft Condensed Matter**

Programme director: Prof. D. Bonn

Research staff 2009: 11 fte

Assessments:	Quality:	5
	Productivity:	5
	Relevance:	5
	Viability:	5

The research focuses on soft mesoscopic materials, also known as complex fluids. Examples of such systems are colloids, emulsions, polymers, surfactants. The behaviour of complex systems arises from a multiplicity of simultaneous interactions between many particles or molecules. The research on the key issues is carried out in collaboration with other groups:

- Collective behaviour in water: with Amolf and HIMS
- Cooperative behaviour and kinetics of aggregation in systems with complex interactions: with HIMS
- Collective behaviour and mechanical properties of compacted granular and glassy systems: with ITFA and HIMS.

The Van der Waals–Zeeman lab at UvA has been well known in the field of colloids and soft matter physics before suffering from departures and retirements. Within the period covered by this review the soft matter group has been completely rejuvenated with the addition of several “young” tenured and tenure track positions. Their interests span a wide swath of the field but of course not its entirety. Although many systems are studied, there is a focus on elasticity and rheology of soft systems especially in the presence of disorder. There are plenty of applications for this research, from food to oil recovery, to granular flow, but there is also an outstanding fundamental physics question: how can a disordered material be rigid? We know that a crystal must be rigid because its broken translational and rotational symmetry mandates elastic constants. A disordered system without broken symmetry needs a different and as yet unknown reason to be rigid. Thus the problem of glasses, yield stress fluids and sands, the meat and potatoes of this group’s research, attacks a basic physics problem head on. Experimentally their strength lies in microscopy and scattering, the pillars of the field.

Quality

This group in collaboration with Dave Weitz’ group at Harvard have taken a leading role in the study of colloidal glasses. They have an internationally leading presence in the field of multiple scattering of waves (optical, acoustic, elastic, electromagnetic) from multiple sources, with interaction and support from the oil industry. They are a top group in rheology (elastic and viscous responses) especially in thixotropic fluids and quicksand, materials whose resistance to flow is not only stress and frequency dependent but history dependent as well. A breakthrough was the idea that aging and reparation of bonds is responsible for the behaviour of many such materials. These studies address yet another fundamental problem, the crossover from a dense suspension of particles, interacting viscously, to a slurry where particles touch and interact by friction. The group has also perfected new tools for studying materials on the micron to millimeter scale, Magnetic Resonance Imaging for studying the structures and dynamics of granular material, analysis of Confocal Microscopy for colloidal system and coupled seismic-electromagnetic sensing and correlation techniques for composite materials and the oil industry. While many groups are studying critical Casimir forces, here there are beautiful experiments making use of the critical Casimir forces to programme and control the interactions between colloidal particles.

Productivity

This relatively small group has succeeded to place many publications in high profile journals such as Physical Review Letters, Nature and Science. Moreover, the committee was particularly impressed by the fact that, in addition, this group has followed up such preliminary research reports by substantial longer original papers and review articles.

Relevance

The group produces a growing number of graduate students trained in modern techniques relevant to both fundamental science and industry. There is an impressive outreach programme with popular demonstrations for the public. An example is the shear thickening cornstarch bath where students and the public can run across a bath of cornstarch in which they would sink if slowing walking. There are strong interactions with industry to the extent that several of the students have support from industry or are employed by industry and sent to get their advanced degrees with this group. According to the tenured staff there is so much offer of industrial support that most of it is rejected and only the projects with the most interesting science are pursued.

Viability

This is a young energetic group with evident internal and external, national and international academic and industrial collaborations. The group is still growing in reputation and number of students. The group is small and will benefit from the addition of an equal quality tenure track position.

Programme UvA 3: **Quantum Gases & Quantum Information**

Programme director: Prof. J.T.M. Walraven

Research staff 2009: 8.2 fte

Assessments:	Quality:	5
	Productivity:	3
	Relevance:	3.5
	Viability:	3

The group explores novel quantum few-body and many-body phenomena with ultracold atoms, both experimentally and theoretically. Important aspects are the role of quantum statistics, dimensionality, many-particle entanglement and decoherence, and quantum simulation of open problems inspired by condensed-matter, nuclear and astrophysics. There are two main themes:

- novel regimes of strong interaction in quantum gases. The research focuses on mixtures of quantum gases and long-range interactions induced by Feshbach resonances. The aim is to influence pairing, trimer-formation and many-body phenomena. Tuneable interactions can also be realized in one-dimensional (1D) bosonic quantum gases by confinement in atomic waveguide structures. This enables comparison with exact theory (thermodynamic Bethe Ansatz) and the investigation of novel forms of spin dynamics.
- the use of coherent interaction between cold atoms. They investigate ways to develop a quantum simulation and quantum information science platform, where information is stored in hyperfine ground states but processed using Rydberg states.

The Van der Waals–Zeeman lab at UvA has a long and excellent tradition in atomic physics. The present group whose focus has changed to cold atoms in controllable condensates for basic understanding of interacting systems and laying the foundations for quantum information has continued this tradition. Individually their accomplishments are equal to any but at present they don't have a big enough group to be competitive with institutes that have been set up in other countries. Presently the Netherlands has not emphasized quantum gases as a priority research area and the group therefore must look to EU funding to continue. The group has been active with collaborations and joint grants with the UvA theory institute and for fabrication with the nanocenter partnered with Amolf.

The fundamental aspects of the research have been quite successful with experiments on Feshbach resonances in cold two particle mixtures of fermion gases and Efimov states (bound trimers, where pairs are unbound). There have been interesting studies of cold atoms on surfaces, chips, and novel patterned magnetic arrays used as traps and shift registers for possible use in quantum computing. The 1/5 position of Shlyapnikov has been very helpful for theoretical support and collaboration and has produced some exciting theory.

The transition from the old lab to the new building was difficult but according to the group it is an enormous step forward in having the labs close together and for fostering collaborations internally and with the theory group.

The magnetic chip work of Spreeuw and Van Druten is excellent and could constitute the real future for this group. Parts of the group seemed to have suffered from long-time absences and approaching retirements.

Quality

The quality of the research of this group is exceptional. The group is small but in general has better, more original ideas than its competitors. There is a nice balance between the fundamental work and developments that might be used in applications to quantum information.

Productivity

The Committee viewed the productivity of this group as low in comparison with the other experimental groups that we rated, in spite of the reasonably high bibliometric figures. They have a lower number of PhD students and postdocs with respect to the 5 faculty members than comparable groups. The number of postdocs has dropped from a respectable ~6 in 2004 to ~1 in 2009, but the number is now back up to 5. The total number of refereed publications in 2009 was only 8, well below what such a group is capable of.

Part of productivity is producing new funds in the form of FOM grants. Here we note that the long-term funding, headed by Walraven, seems about to run out in 2011. The appointment of a new professor in the team offers an opportunity to initiate a new FOM programme.

Relevance

The work of this group is primarily fundamental, but presently there are relevant applications in terms of perfecting time keeping with atomic clocks, precision frequency measurements and GPS navigation. It is not clear that the group is making contributions to applications in these areas. There are also future potential applications to quantum cryptography and computing.

Viability

A theoretical leader, Shlyapnikov, and an experimental leader, Walraven, will retire in the coming few years. The Committee felt that the preparation for these major transitions has been inadequate, with a search just commencing.

Programme UvA 4: **Particle Physics, Cosmology and Quantum Gravity**

Programme directors: Prof. E. Verlinde, Prof. E. Laenen

Research staff 2009: 17.7 fte

Assessments:	Quality:	5
	Productivity:	4
	Relevance:	4
	Viability:	5

The objective of this programme is to unravel the physics of Nature at its smallest and largest length scales. The fundamental nature of elementary forces, especially of Quantum Gravity, is explored from a string theory context. Gravitational physics are related with the physics of strongly interacting quantum matter through a mathematical connection known as AdS/CMT. An important research objective is to employ these new insights and study its implications for cosmology and areas of physics such as high temperature QCD and condensed matter theory. The area of Particle physics related to LHC experiments is also addressed, in part with links to Nikhef, focussing in particular on top quark physics, as well as research into Cosmology and astroparticle physics. The main theme being pursued is the issue of non-gaussian fluctuations in the CMB spectrum, which would reveal much about inflation, and the nature of Dark Matter.

Quality

The scientific activities and results of this research programme are internationally very well recognised and in fact belong, in the full range of research topics pursued, to the top-5% of comparable research efforts and results world-wide. The same is true for a number of group members who not only lead the research in these fields, string theory and particle physics phenomenology, in the Netherlands, but who belong to the leaders of their fields in Europe and the world. In string theory, new and original fields were defined e.g. with fusion rules in CFT (conformal field theory) – the Verlinde rules -, strings in black holes, the entropic formulation of gravitation, topological strings and matrix models. In particle physics phenomenology, new Monte-Carlo tools were developed that allow precise simulations of specific reactions at the Large Hadron Collider (LHC), which are widely utilised in the international effort to analyse LHC data in terms of precision tests of the Standard Model (SM) of particle physics and searches for possible new physics signals beyond. The number and broadness of results as well as their scientific quality is regarded to be outstanding. The impact of these results on other studies in similar fields, by other scientists world-wide, is regarded to be outstanding, too. The scientific success and impact of this programme is also visible from the very impressive list of prizes and funding programmes recently awarded to (members of) the group – as the Spinoza price, VIDI and VICI grants, an ERC advanced grant.

Productivity

The scientific productivity of this research programme is, in accordance with the excellent quality of the results in general, very high and also meets highest international standards. About 40 publications per year, most of them in peer-reviewed journals, 3-4 PhD theses annually, and especially the outstanding quality of these publications in general, aim for the highest marks also in productivity. The Committee, however, realised that most of the refereed articles are published in one journal only, Journal of High Energy Physics (JHEP), which has a viable impact factor of 6.0, but which is hardly known in physics branches outside of string theory and particle physics phenomenology. The Committee considered exclusive publication in a journal actually founded within this very same field to be too narrow and not to be of the very highest credibility. The Committee also recognised absence of summary and review articles about these fields, authored

by members of this programme, as another factor that led to reducing the very highest possible mark (a “5”) to “4” in order to account for these deficiencies, in comparison to other groups and programmes regarded in the course of this review. The programme is considered as nationally leading, and of high international recognition.

Relevance

While being of highest relevance to the field of science, string theory and particle physics phenomenology as a whole have, in general, limited direct impact on society. This research programme has, however, very large secondary impact on societal matters through the large number of extremely well-trained and successful PhD students and post-docs, most of which actually do or will not stay in basic science but will take over positions in many fields of society. The fields of string theory and theoretical physics are known to interest and attract many young students, often the best of their age group, and therefore motivate many talented young minds for basic research and unconventional thinking in general. There is also huge public interest in the topics studied in this programme, and the group is in fact very actively engaged in public outreach programmes.

Viability

The groups engaged in this programme made a very professional, extremely motivated and dynamical impression on the board members. The size and age structure of the groups are regarded to be very healthy, as are the future plans presented to the board. Recent appointments of several world-renowned scientists with undoubted future potential, and perspectives for further appointments, secure the long-term scientific programme and excellence of the group. Several earned prizes and funding programmes, adding to about 10 M€ in total, will enable to pursue a very solid and lively science programme for the coming years. The programme is excellently networked both on the national and the international scale.

Conclusion

In total, the Committee rates this programme to be of highest international visibility, scientific quality and impact. Although being 100% knowledge- rather than application-oriented, it has very high impact also on societal and non-scientific aspects of life. The future prospects of this programme, assuming continuation of support by the university and funding sources, are regarded to be excellent without any doubt.

Programme UvA 5: **Quantum Matter and Complex Systems**

Programme directors: Prof. K. Schoutens, Prof. B. Nienhuis

Research staff 2009: 10 fte

Assessments:	Quality:	4
	Productivity:	4.5
	Relevance:	4
	Viability:	4

Central to this programme is the study of collective effects in quantum and classical many-body systems. The research on low dimensional quantum matter is under the direction of Kareljan Schoutens, Aad Pruisken, and Jean-Sébastien Caux. The research on complex systems and collective phenomena is directed by Bernard Nienhuis and Theo Nieuwenhuizen. The different programmes are largely collaborative, both within the Institute of Physics at UvA and also outside. The programme is integrated in the Dutch School for Theoretical Physics, as well as the Delta Institute for Theoretical Physics at Amsterdam, Leiden, and Utrecht. They also have collaborations through the ESF INSTANS programme, where again Schoutens has a leading role within the Netherlands. Other collaborations include some of the international leaders in these areas, such as David DiVincenzo from IBM and Microsoft Station Q. Collaborations within the Amsterdam IOP include multiple interactions with UvA 4, and many collaborations with all three experimental areas (UvA 1-3).

Quality

We find that taken together, this group has clear national leadership, and is internationally competitive. One measure of quality is honours and distinctions, and here the group has done quite well in the Netherlands. They have captured one VICI and two VENI grants from NWO, as well as nine FOM projects or Projectruimte. Schoutens has been elected to the Royal Society, and there are also several other awards and honours.

In the area of Quantum Matter, emphasis within this group has moved in the direction of cold atomic matter, quantum information and quantum computation. Recent topics have been (i) quantitative measures of entanglement in quantum matter (ii) the characterization of quantum critical behaviour in the quantum Hall effect (joint with programme UvA 1), and (iii) topological phases and topological quantum computation. These projects align well with the national research priority of Quantum Matter and Quantum Information.

In the area of Complex Systems, the programme studies granular and colloidal matter. Investigation into the nature of the jamming/yield transition is done in collaboration with the Soft Matter group of the WZI (programme UvA 3). This applies to a wide range of complex transport phenomena, from traffic to glasses. A new initiative tries to understand the self-organization of virus capsids. These projects align with the national research priority of Soft Matter.

High quality is demonstrated throughout the programme. Here are just a few examples that demonstrate this: J.-S. Caux has begun a VICI project on Bethe liquids, as a new way to study dynamics both in and out of equilibrium. B. Nienhuis is studying the formation and thermodynamic stability of viral capsids, and in a different collaboration he is studying dynamics properties of colloidal glasses. This is a direct measurement of free energy in dense colloidal suspensions, with relation between force chains and low frequency vibrational modes. These projects require close couplings of theory and experiments. Nieuwenhuizen has projects ranging

from multiple light scattering and the thermodynamics of glasses to fundamental “beyond the quantum” projects with UvA 4. Pruisken has taken on topological principles in the theory of Anderson localization. And K. Schoutens has made some progress on topological methods for quantum registers.

Productivity

The output of this group has been trending upward in the last year of the reporting period, with higher quality publications and excellent postdoctoral placements as important evidence of this. There was a rather substantial but temporary dip in the overall staffing and publications, reaching a low point in 2008. This was at least in part due to funding, which has now been increased through several nationally funded collaborative projects. Also, increase in activity can be connected to the arrival in 2007 of J-S Caux in the group, and his more recent VICI award. In addition, a VENI was awarded to Snoek and to Pozsgai. We further note that the choice of Quantum Matter and Quantum Information is well-positioned for resources from the Sectorplan Physics and Chemistry.

Collective quantitative productivity measures are therefore trending upward. The group has rightly noted that the number of post-docs and PhD students in the programme should be higher. A new tenure track professor will join the group in September 2011, with a particular emphasis to continue to strengthen the quantum matter and quantum information area. We feel confident, therefore, that the upward trend should continue, thus justifying a high productivity score.

The funding of this programme is interwoven with other groups in the Institute of Physics. Theory (programmes 4 and 5 are considered together in the ITFA, and it appears to be approximately equally split between tier 1 and tier 2 funding. Much of the tier 2 funding is collaborative, and contributions to UvA 5 are not separated in all cases. It is clear qualitatively that this group gets a reasonable share of the collaborative funding in the areas where it participates. ITFA as a whole has successfully competed for nine Open Competition (projectruimte) Grants at an average of 300k Euros.

Relevance

Relevance scores in this group come primarily from their excellent record of contributing materially to the success of other research groups through strategic collaboration; and a related measure, the placement of graduate students in productive roles following their tenure in the group. The research staff consists of approximately five positions, with stable student participation and rising funding. The total research staff is approximately 11 fte. This group presented its tracking of employment following the PhD as one important evidence of relevance. They point out that out of 93 PhD's in the Dutch Research School for Theoretical Physics during the review period, 65% find employment in postdoctoral academic positions, while 28% go immediately to the commercial sector or to government.

In addition, the increased visibility of the Amsterdam Summer Workshops has helped this group. They are organizers of the biennial Amsterdam Summer Workshops on *Low-D Quantum Condensed Matter* (2005, 2007, 2009).

Viability

We find that the viability of this group is quite high. The group has settled on a programme focus that is in line with several national priorities in science, and therefore should be supported in the intermediate term. In addition, the senior staff is by and large in their early to mid-career, therefore lending stability to the group. The current growth of an additional faculty member

makes this even better. Funding is growing, and the number of students should be expected to grow as well as a result. Finally, the group should be commended for their high degree of collaboration within the Institute of Physics. This not only cements relationships across the UvA programmes, but also will serve in the long run to give the UvA the best opportunity to take early and optimal advantage of opportunities close to their research expertise. We only caution that our optimistic view presupposes that the programme growth seen in the past two years can be sustained, but we believe that the group is committed to this and knows how to accomplish it.

Conclusion

This group deserves its ranking as the leaders in the Netherlands in this area. If it continues on its current upward trajectory, we are confident that it will achieve real international leadership in its chosen areas as well. Specific recommendations to achieve this include: continued efforts to strengthen the complex systems and collective phenomena focus area, through new faculty (currently a search is planned) and through the special mechanism of extraordinary professorships. Also, it is clear that the fortunes of this group depend very seriously on the level of research funds available for competitive grants.

Programme UvA 6: **Particle and Astroparticle Physics**

Programme director: Prof. S. Bentvelsen

Research staff 2009: 25.1 fte

Assessments:	Quality:	5
	Productivity:	5
	Relevance:	4
	Viability:	5

The research objectives for the Institute of High Energy Physics (IHEF) are the investigation of the properties of the fundamental constituents of matter and their interactions and the use of particle messengers to gain insight into high energy astrophysical processes. To accomplish this, two main directions of research are followed:

1. Experiments making use of the world's foremost accelerators in terms of centre of mass energy and luminosity. In particular, participation in the ZEUS experiment at the HERA electron-proton collider at DESY in Hamburg, participation in the D0 experiment at the Tevatron collider in the vicinity of Chicago, and participation in the ATLAS experiment at the Large Hadron Collider at CERN in Geneva. Activities of IHEF include detector construction, data analysis and development of theoretical predictions.
2. Astroparticle physics. IHEF is participating in the Antares experiment, a water Cherenkov experiment in the Mediterranean Sea, which aims to unravel astrophysical processes through the detection of neutrinos.

The research benefits from the close cooperation with the national institute for subatomic physics, Nikhef.

Quality

The scientific activities and achievements of this research programme are internationally very well recognised and compare, without doubt and in the full range of research topics pursued, very favourably to the top-5% of comparable research efforts and results world-wide. The visibility and impact of this group, and of many individual UvA scientists as well, in several international large-scale experiments and collaborations is significantly higher than their percentage of collaboration members in terms of manpower. Although these achievements are obtained within the (larger) groups of Nikhef, the board acknowledged that UvA scientists in this endeavour play a leading role in planning, designing, building and running the various projects, as is visible e.g. by the many leading positions and convenorships UvA scientists had and still have in these projects. Especially the ATLAS group plays a significant role in this multinational project. The amount and quality of forefront particle detectors and modules built and managed by this group is outstanding. The group is also strongly engaged in harvesting the fruits of these efforts through their engagement in forefront physics analyses of ATLAS and Antares data, as well as in analysing data from previous, now (or soon to be) discontinued projects like ZEUS and D0.

Productivity

The number, quality and impact of technical contributions and scientific publications out of this programme are excellent, and again compares well to the top 5% of institutions or groups of this field world-wide. While these publications are, in general, products of large international collaborations with large to even huge (e.g. in terms of ATLAS) lists of authors, the UvA group is known within these collaborations and beyond, to be strong leaders within these international endeavours. This manifests for instance in several convenorships of important physics study

groups and in many presentations of UvA scientists at international conferences, representing large international collaborations. Results are published in world-leading and recognised journals.

Relevance

The direct societal relevance of basic and knowledge-oriented research is normally very limited. In the case of the programme, significant technological advancements have been achieved in the field of developing particle detectors and read-out electronics capable of digesting highest rates and amounts of data. These developments have impact e.g. on the development of particle detectors for medical purposes like the Medipix project. As typical in this field, however, such developments are not protected by patents, but are left open and available for all kinds of scientific and commercial uses. Education and technical as well as scientific training of large numbers of PhD students and post-docs, and the impact of this human capital on society and industry, makes the societal value of this field recognisable in many fields and aspects of life. The outreach activities of this programme, documented by an impressive number of projects, are excellent and in fact hard to outperform. Altogether, the board regards the sum of these achievements, according to internally defined indicators, to be of very high international and leading national scale.

Viability

Future prospects of this programme are regarded to be of highest national and international standing, and are in fact excellent given the scientific importance, international standing and future relevance of these projects – ATLAS as well as Antares/KM3NeT . The programme is at the forefront of scientific research in both collider physics at the very highest energies, and in high energy cosmic neutrino physics. The complementarity of these programmes ensures long-lasting viability in these fields, and offers very interesting future prospects also for students and young post-docs. The age structure of this group appeared to be very favourable and extends well into the future. The team made a very motivated and dynamic impression to the board members.

Conclusion

The overall impression of this programme is excellent and of highest international standing, comparing well to the top 5% of institutions in this field world-wide. The symbiosis with Nikhef and the concentration of basically two complementary programmes in particle and astroparticle physics, together with the extreme international networking, makes this programme an extremely attractive and fruitful part of basic research and student education in the Netherlands.

8A. INSTITUTE LEVEL - VU University Amsterdam

University: VU University Amsterdam
Faculty: Faculty of Sciences (FoS)

1. The institute

The Faculty of Sciences (FoS) offers research and education in the natural sciences, mathematics and computer science. The research of FoS is organized in four Departments: Computer Sciences, Physics & Astronomy, Chemistry & Pharmaceutical Sciences, and Mathematics. In addition to this departmental structure, many research efforts within the FoS are embedded in five interdisciplinary/interfaculty research institutes: the Network Institute, Neuroscience Campus Amsterdam, the Institute for Lasers, Life and Biophotonics (LaserLAB Amsterdam), the Amsterdam Institute for Molecules, Medicines and Systems (AIMMS) and the Centre for Advanced Media Research Amsterdam (CAMERA).

The Department of Physics and Astronomy was established in 1930. Initially its activities were focused entirely on nuclear physics. Gradually other research activities were started and the nuclear physics activities were terminated, while keeping a group in particle physics that became associated with the National Institute NIKHEF. In the 1970s and 1980s research groups in condensed matter, biophysics, astronomy, and laser physics were started. At the turn of the century it was decided to terminate activities in astronomy and start instead a new effort focusing on the life sciences: Physics of Complex Systems, with a focus on single molecule and cell-level biophysics. More recently, the VU also began a new initiative in Energy, building on parallel efforts in the Biophysics group on photosynthesis and in the Condensed Matter group on Hydrogen storage.

The department strategically positioned itself in the Sectorplan to focus on physics of life, physics of energy and physics of light and matter. All new investments will be tied to activities in life and energy science. This is in line with the major themes of the VU University as a whole, which include “Human Health and Life Sciences” and “Sustainable Earth, Energy and the Human Environment”.

The research of the VU Physics Department is in its entirety embedded in two institutes: the Institute for Lasers, Life and Biophotonics (LaserLaB) and Nikhef. These institutes have their own research management, a well-equipped infrastructure and innovative capacity.

Assessment/remarks

The academic reputation of the physics institute is internationally very high, and they are well-positioned within the Netherlands to work in three of the central themes in the Sectorplan: Physics of Life, Physics of Energy, and Physics of Light and Matter. These match quite well with the local strategy of VU to emphasize “Health and Life” and “Sustainable Earth/Energy/Environment.”

The Committee found good coordination with other physics institutes in the country through LaserLab Amsterdam and LaserLab Europe, where there are significant developments in metrology of use to the whole science enterprise, and the Nikhef Institute, where there are significant contributions to both VIRGO and LHC-B.

2. Quality and academic reputation

In the period 2004-09, 5 VICI grants (De Boer, Eikema, Wuite and adjunct professors Ten Wolde and Linnartz), 7 VIDIs (Wuite, Peterman, Iannuzzi, Bethlem, Kennis, Dame and adjunct

professor Koenderink), and 2 ERC grants (Bethlem and Iannuzzi) were awarded to VU faculty. Van Grondelle was appointed as special KNAW-professor, with a grant to appoint a young professor in the field of photosynthesis/energy for 5 years. Both Griessen and Van Grondelle were invited to hold the prestigious Physica-lecture (only one physicist per year).

Assessment/remarks

The recruiting and the promoting of young people and development of staff, which is so critically important in a university research department, is going very well at VU. One piece of evidence for this is the extremely large number of personal VIDI and VICI grants. Just over this six year period, no fewer than three faculty members received both VIDI grants early in the period, and VICI grants towards the end. The department should take great pride in this.

3. Resources

A significant factor is the decrease in direct funding from the university of over 7% per year in 2004-2009, which has led to the virtual elimination of university-funded PhDs. This accounts for a large part of the nearly 10% decrease in total staff during the review period, much of which has been in PhD students.

The low level of direct financing will threaten the level of the existing mechanical and electronics workshops and support. The status of the Sciences building at VU-campus is becoming outdated and poses a threat for future advanced research.

Assessment/remarks

The Committee had some complete but rapid tours, which convinced us that the Physics programme is making the very best use of some very challenging older infrastructure. The Committee was particularly taken with the large number and variety of laser installations, some of which would benefit from better environment because of the needs of precision metrology through the use of ultrastable lasers.

4. Productivity

The results of the CWTS-analysis show that the VU programmes under review have produced 893 articles in Web of Science journals in the 4 years of the review period. These articles were cited 13177 times, not counting self-citations. The mean citation score is 10.03 for Atomic and Laser Physics, 22.71 for Complex Systems, 7.63 for Condensed Matter, 13.93 for Biophysics and 15.68 for Subatomic Physics. The highest number of papers among the 10% most frequently cited papers is 54 for the group Complex Systems. The number of articles per full-time equivalent of academic staff ranges from 2.1 to 1.5 in the VU programmes under review, with an average of 1.9. This is the same as the average output per fte in all the programmes in this Physics review.

Among the high-impact output in 2004-2009, there have been 14 articles in Nature and Science, as well as over 200 in Physical Review Letters, of which approximately 80% were from the Subatomic Physics programme.

In the review period of 2004-2009 there were 15 patent applications, compared with just 2 in the previous period of 1996-2002.

Assessment/remarks

The productivity of the VU programmes under review was assessed as very good to excellent.

5. Societal Relevance

While the major aim of VU-physics is to excel in the academic arena, two staff members hold important patents in the field of biomedical optics, De Boer in Optical Coherence Tomography instrumentation and Iannuzzi in relation to his development of the “fibre-top cantilever” instrument with a number of medical applications as well. The latter is in the process of setting up a spin-off company based on his invention.

The Atomic, Molecular and Laser physics group is involved in a FOM-industrial partnership programme with companies ASML (Lithography), TNO and the Netherlands metrology institute VSL, while it is a partner in the MEMPHIS-“Smartmix” consortium (Merging photonics with electronics), funded by the ministry of economic affairs with 28 M€. Also a number of research projects are carried out for the European Space Agency in relation to future satellite projects (SCIAMACHY, ADM-Aeolus, and on length metrology). A former PhD student has started a company (OGS Systems). The “Fascination of Light” exhibition was organized in Amsterdam by LaserLaB.

Assessment/remarks

The societal relevance of the education, the valorisation efforts and the outreach activities are highly appreciated.

6. Strategy for the future

Activities in astronomy and in physics-applied computer science have been terminated, while new activities have been defined in complex systems and biomedical optics. In the near future, the existing group in “condensed matter physics” will be transformed and redirected towards “physics of energy” with a focus on photo-conversion materials. The four new positions available through the Sectorplan will be used to further strengthen research in “life” and “energy”.

The department maintains a dedicated activity in particle and astro-particle physics with a high profile and successful group embedded in the structure of the national research institute NIKHEF. Key research areas are here: matter-antimatter physics at LHC-b and gravitational waves associated with VIRGO.

Over the past few years, the department of physics has shifted its hiring priorities toward a focus on identifying promising young scientists, hired increasingly in tenure-track positions. This focus on hiring younger faculty has helped to weather severe budget cuts in structural funding, as many of these recent hires have been very successful in raising research funds. This is particularly true in the case of personal fellowships, with numerous VIDI, VICI and ERC grants.

The nation-wide Sectorplan strongly emphasized complementarity between universities. In this regard, the two universities in Amsterdam were very positively viewed for their largely non-overlapping activities. The UvA has chosen, for instance, not to emphasize biophysics, a major focus of the VU. Additionally, the VU has chosen to shift increasingly away from condensed matter and materials science toward energy oriented research. Areas of continuing overlap include particle physics (with both UvA and VU efforts embedded in NIKHEF) and atomic and laser physics. Here, there has been enhanced cooperation, for instance, with several UvA groups participating in the LaserLaB, based at the VU.

The department is committed to improving the representation of women at all academic levels within the department. In 2010, Marloes Groot was promoted to full Professor, and Roberta Croce (also recipient of a VICI award in 2011) was recruited as full Professor, beginning March 2011.

The restructuring of the Physics department and its refocusing of research topics will undergo another major step during spring 2011. It has been decided to terminate activities in “classical” solid-state physics and re-direct to a programme in solar fuels. From mid 2011 there is a strong research team in Physics of Energy, focusing on BioSolar Cells and (anorganic) Solar Fuels. This team has been strengthened by a number of project grants from the Netherlands programme "Toward BioSolar Cells", by a new FOM-programme "The Thylakoid Membrane” and the ERC advanced grant of Prof. Van Grondelle. In addition a new research programme in Biomedical Imaging will be defined, concentrating the activities of De Boer (Optical Coherence Tomography), Groot (Neuroimaging), Iannuzzi (Fiber-top cantilevers) and Verdaasdonk (VU medical centre). The development of a soft-röntgenlaser (Eikema) for life science imaging is also associated with these activities.

According to the self-assessment report, the funding of the research activities is at a high level with various VU-physicists coordinating FOM programmes and a number of young VU physicists who have acquired major personal grants (ERC, VICI, VIDI). The relatively low level of influx of bachelors students into the physics programme, resulted in a low level of direct funding, but this is now largely compensated by the activities of the physics department in the bachelors programmes of Medical Natural Sciences and Science Business and Innovation, which comprise 50% and 30% physics-related courses, respectively.

The restructuring of the bachelor of physics programme into a joint activity with the University of Amsterdam, with the VU emphasizing the themes of life science and energy, is expected to help attracting a larger number of students. Still, the self-assessment report states that the low level of direct financing will threaten the level of the existing mechanical and electronics workshops and support, and that the status of the Sciences building at VU-campus is becoming out-dated and poses a threat for future advanced research.

Assessment/remarks

The Committee is very positive about the local coordination between VU and UvA. While they are maintaining their independent points of view, at the same time they engage in both joint research and joint educational programmes to the benefit of the whole country. The very recent decision to have overlapping academic programmes for the Bachelors degree is extremely positive. Harvard and MIT have been doing this for a number of years and the benefits to physics programmes are very strong.

7. PhD Training

The PhD students are mainly trained within their research groups. The training includes seminars at group meetings. In most cases they attend an international summer school in the first year. Students are encouraged to follow courses on academic skills (writing, presentations) as provided by university and FOM. In addition, theory students in all programmes are automatically part of the Dutch Research School of Theoretical Physics (DRSTP), which organizes an annual school for students in the first two years of the PhD. The DRSTP reviews the activities and progress toward the PhD on a yearly basis. Likewise, experimental particle physics students are part of Dutch Research School for Subatomic Physics (SAF), which provides similar support, supervision and training programmes.

The PhD students have generally been successful finding their way into various careers. Some graduates have found positions in industry (Philips, ASML, JPK); several are pursuing a career in consultancy (Roland Berger Strategy Consultants); many students pursue a career in academia and find postdocs at leading institutions (e.g., Imperial College, MIT, Stanford University, Princeton

University). Recent graduates from this period have already obtained excellent faculty or group leader positions.

Assessment/remarks

The Committee had a very productive visit with the students. They are quite happy, but had some suggestions about creating opportunities for them to interact with each other, across the groups. A particular suggestion was a grad-student run journal club.

8B. PROGRAMME LEVEL - VU University Amsterdam

Programme VU 1: **Atomic, Molecular and Laser Physics**

Programme directors: Prof. W. Ubachs, Prof. K.S.E. Eikema, Dr. W. Vassen, Dr. H.L. Bethlem, Prof. T.D. Visser

Research staff 2009: 13.73 fte

Assessments:	Quality:	5
	Productivity:	4.5
	Relevance:	4.5
	Viability:	5

The research focuses on the fundamental interaction of light and matter, on the development of advanced laser sources and on cooling, trapping, and manipulation of atoms and molecules. The programme had two subprogrammes:

- Precision metrology and manipulation of atomic scale systems: the development and use of the most precise tools of physics available today to test the current physical understanding of matter.
- Optical coherence theory and non-linear dynamics: theoretical research on the use of spatial coherence to tailor the properties of light fields and their interaction with sub-wavelength structures.

The programme is part of LaserLab Amsterdam, which itself is associated with LaserLab Europe. The main reorganization since the previous review has been to phase out the theory component, which was represented by the Visser group (now at Delft) and to concentrate the programme to contribute to the VU Focus Area of Physics of Light and matter, a main item in the University's current "Sectorplan." Bethlem has also joined the group from Berlin.

Within this broader area the group specializes in fundamental light-matter interactions, and they have identified a number of scientific targets where they can establish a world-leading position: Search for cosmic-scale variation of fundamental constants; Tests of QED in atoms and molecules; Control of atoms and molecules; ultrastable (~ 1 Hz) lasers; VUV frequency combs; and frequency standard distribution throughout Europe. We found that this list is appropriate, with a good balance of fundamental science and metrology, and excellent display of the group's expertise.

Quality

The quality is at the "best in the world-class" level in the area of fundamental studies where the group has decided to concentrate its efforts. The metrics support this both in paper quality and normalized citation indices, but we were also strongly influenced by our interview which delved into some of the details of the measurements. The search for variation in the fine structure constant focuses on a critical element in that determination, namely the ratio of the electron to proton mass. This can be deduced from precision spectroscopy on states in molecular hydrogen and its isotopes, done in the laboratory and also compared to astrophysical observations of deep space. The group has come up with a novel and potentially much more sensitive test based on transitions in methyl alcohol that are exponentially sensitive to the proton mass, which could be a game changer in this field.

This group is particularly strong because it can draw different expertise from the different senior staff, and combine them in new ways. A particular example of this is the combination of UV metrology and cold molecular fountains. We observe that the current precision of less than one part per billion, which is already competitive in the measurements of the proton-electron mass ratio, stands to be improved substantially in this lab.

Other similar examples of world-leading activities include the frequency combs in the extreme ultraviolet, where the group has developed a unique new method based on OPCPA that can increase the spectral brightness of these sources substantially while maintaining their spectral precision. Yet another example is the development of degenerate quantum gases of both metastable $^4\text{He}^*$ (a boson) and $^3\text{He}^*$ (a fermion).

The group demonstrated spectacular Hanbury-Brown and Twiss-type measurements showing how the statistics lead to dramatically different behaviour at low temperature. This then leads to the ability to make world-class measurements of the nuclear size through optical spectroscopy at the part per trillion level. This is truly outstanding work, with both high visibility and high impact.

Bethlem has both VIDI and ERC funding and has focused on precision measurements in cold molecules using the Stark deceleration methods that he has developed previously in Berlin.

Productivity

This group has very high productivity, which must be considered in the context of the precision measurement community, which always emphasizes quality over quantity. Their absolute productivity metrics with regard to papers therefore place them more in the middle of the Physics programmes that we reviewed rather than at the absolute top. However, we argue that their productivity is much higher than this, hence the 4.5 ranking. There are no weak examples among the four subprogrammes of the senior staff. The number of papers per fte is only 1.5, but those papers have such a high impact that the normalized citation index (MNCS) of 1.77 places them far above the norm of excellence in their field. Other elements of high productivity include the steady production of both papers and students; a marked expansion of activities that all relate to their expertise in fundamental measurements.

Relevance

Traditionally groups that focus on precision measurements of fundamental constants and symmetries have a more difficult time demonstrating near-term societal relevance, but this group is an exception: we determine that the relevance factor is extremely high, nearly at the top grade. The reason is that there is an appropriate large emphasis on the development of advanced laser techniques and sources of control; and the group has found a mode of operation where it can easily and naturally export this very specialized knowledge to applied projects and problems throughout the Netherlands and Europe. External links are made easier by the embedding in LaserLab Amsterdam, LaserLab Europe, as well as a number of other external collaborative programmes such as the FOM programme with KVI. Here there is only space to briefly summarize our findings in this area.

This group is leading the proposal for a European Fiber Network stretching from Amsterdam to Italy. There is at least a two-fold benefit here: this could help relate clock experiments in different locations for sensitive tests of fundamental constants; and at the same time it will prove a reference standard for Europe. A 260 km link with KVI has already been established. Additional activities in Applied Science include the ESA funded “Wind” mission measuring atmospheric scattering; a programme to study interstellar chemistry (carbon change); and the assistance in commercial development of fibre comb lasers, with Menlo Systems and IMRA.

Other applications of soft x-ray technology related to this are water window imaging and lenseless holography. The highly developed activity in generating ultraviolet radiation is currently leading to a new nationally funded programme in laser-based microscopy for imaging in the life sciences.

These are high value applications, and the group seems poised to make an important contribution here. One of our few concerns is that the group has not previously been culturally attuned to the filing of patents, but these new applied innovations really start to need intellectual property protection. We urge the group to begin patenting its technical innovations.

Viability

There are no concerns with the viability of this group. Following its restructuring referred to above, they have established a senior staff with youth, vitality, and common purpose. There is a good distribution of ages, and clear paths to succession, which will hopefully not even be necessary for the next decade.

Programme VU 2: **Complex systems**

Programme directors: Prof. J.F. de Boer, Prof. F.C. MacKintosh, Dr. ir. E.J.G. Peterman, Prof. G.J.L. Wuite

Research staff 2009: 15.61 fte

Assessments:	Quality:	5
	Productivity:	4.5
	Relevance:	5
	Viability:	4.5

This programme aims to understand and develop quantitative techniques for measurement of complex biological systems, ranging from the single molecule level of cellular constituents to the imaging of whole tissues, using a combination of mostly optical/laser techniques and theoretical modelling. They combine a programme to understand fundamental physics principles governing biological systems, with programmes to help to solve frontier clinical problems using the techniques of the modern physics laboratory such as single particle manipulation.

The programme is subdivided into three groups, which interact strongly with each other:

- Single Molecule to Cell Biophysics focuses on structure-function relationships at the level of single molecules to whole cells.
- Theoretical biophysics and soft matter is currently focused primarily on the theory of the structure and mechanics of the cytoskeleton and similar related structures.
- Biomedical physics is the newest group and is concerned with developing novel optical methods to measure and characterize tissue for the purpose of diagnosing disease.

Our evaluation considers these groups together.

Quality

The first subprogramme developed a special instrument in fluorescent microscopy that enabled them to measure elasticity in a single DNA molecule and detect highly non-linear behaviour. They focus on the quantitative distribution of motor proteins and on the effect of such multiple pull.

The second subprogramme represents an interesting combination of physics and biology, looking at the stability of networks, the mechanical skeleton of cells, the balance between dimensionality and connectivity, with the aid of specially developed mathematical models.

The third subprogramme is a new section. They use low-noise optical coherence tomography (OCT) and split light over several wave-lengths. Building on previous work in Boston, they have contributed to the development of an endoscope with a spinning motor at the tip (see VU 3).

The groups are well aware of their outstanding international position and they generally have good complementary collaboration with similar groups around the world. A specific strength is the high level of collaboration between theoretical and experimental approaches that they have achieved. They manage to maintain an excellent balance between fundamental and applied research, and they do not experience these approaches as contradictory.

Productivity

The metrics concerning productivity are extremely high in this group. The mean citation score is 22.71 for Complex Systems. With 54 papers among the 10% most frequently cited papers, this

programme has the highest score of the VU programmes. In addition, 52% of their 184 papers are in high impact journals in biophysics.

The student production is similarly excellent with seventeen students in the years 2000-2005, only two of whom have left the program without finishing. A recent dip in the number of students is explained by the departure of a professor.

Relevance

The contributions of this group create a critical bridge between traditional areas of fundamental physics and all manner of applications in biophysics. This includes investigations of the core physics involved in DNA reactions with proteins, the use of single molecule methods to investigate the physical properties of viral capsids, the mechanism of DNA packaging and genome delivery, studies of non-equilibrium properties of cytoskeletal networks, their nonlinear elastic response, and the consequences of the simultaneous presence of both rigid microtubules and soft filament structures in cytoskeletons.

As the group turns toward biomedical and other clinical applications, the relevance will be more connected to the needs of the medical and clinical communities, rather than the traditional fundamental research communities. A significant consideration will be to choose areas where the science focus of this group is the driving force behind selection of topics, rather than trying to cover topics that are politically popular but not so much affected by science.

There are three license agreements, which generated 5M€ to date, and eight awarded patents.

Viability

The viability of the complex systems group is based largely on how it successfully combines theory and experiment in a collaborative research environment. This has led to a position of strong leadership in biophysics, not only in the Netherlands but also internationally, with many international collaborations. Plans to reinforce this include an increase in the theory effort and in medical imaging. Further strengthening theory has been identified as a high priority.

We also note a healthy distribution of strong mid-career reputation for the senior members of the group and early success of the younger members. The group has garnered two prestigious Vici awards during the period, and has had very good success in attracting funding at the group and personal levels.

Conclusion

We conclude that this is an extremely strong programme overall. It combines excellent science, high international visibility, relevance linking fundamental and clinical work, high productivity metrics, and an excellent record of graduate training. We believe that this group is well positioned to thrive even in an increasingly challenging funding climate in the Netherlands and in Europe.

Issues to consider for the future include:

- finding ways to retain credit for innovation at VU through patenting and licensing technology developed within the group;
- creating programmes that can allow students to easily cross the divide between fundamental science and biomedical applications;
- choosing problems where industry is the beneficiary but science is the lead motivation.

Programme VU 3: **Condensed Matter Physics**

Programme directors: Prof. Griessen (retired 2010), Dr. B. Dam, Dr. R. Wijngaarden, Dr. D. Iannuzzi.

Research staff 2009: 10.75 fte

Assessments:	Quality:	3.5*
	Productivity:	4
	Relevance:	4.5
	Viability:	no score (group will be dissolved)

*) A separate quality score of 4.5 is given for the activities of Dr. Iannuzzi

The research line on hydrogen storage has come to an end because of the retirement of Prof. Griessen and the departure of Dr. Dam. The group will be transformed into a Physics of Energy section, embedded in the other Energy initiatives of VU Physics. The work in the field of sustainable energy, with experiments to investigate water splitting by solar light on surfaces with natural or engineered electrical field configurations, will be strengthened further as soon as the vacancy for a professor in Physics of Energy will be filled in. The group has also worked on several fundamental topics (e.g., Casimir effect, self-organized criticality, search of chameleon fields, physics of avalanches). More recently, the subgroup of Dr. Iannuzzi has developed a proprietary “fibre-top” technology, with promising applications in biomedical sensing. This activity will be transferred to the new Biomedical Imaging group.

Quality

The numerous scientific contributions of the retired Prof. Griessen during the evaluation period have not been presented in the self-assessment report of the group. Dr. Wijngaardens work on superconductivity and self-organized criticality is quite diverse and has been published in a number of good to very good journal articles. However, due to the diversity of the research topics, the activities of this subgroup have not reached a critical level and overall cannot be considered leading nationally or internationally. The work of Dr. Iannuzzi has been similarly diverse in the past, even with some more exotic sidelines (“chameleon fields”). However, this subgroup is internationally leading in the development and exploitation of the promising “fibre top” technology, which has become the focus of the activities in the last five years and has earned Dr. Iannuzzi an ERC starting grant.

Productivity

The productivity within the programme has been excellent in the first part of the assessment period, but has decreased by a factor of two in the second half, despite of roughly constant fte-values and an even increasing total funding. In addition to 125 refereed articles, 9 patents have been filed or granted between 2004 and 2009.

Relevance

Apparently, the group has invested comparatively little effort in public outreach, but instead defines its relevance via patents and patent applications, some of which are close to commercialisation or represent the IP basis for a spin-off company. The latter (“Optics11”) has been founded by Dr. Iannuzzi and has received a STW and a FOM Valorisation Grant. During the site visit, Dr. Iannuzzi presented to the panel several innovative product ideas based on the fibre-top technology, which indeed could become very relevant in biomedical sensing and imaging.

Viability

Here no score was given because the existing Condensed Matter Physics group will be dissolved and, thus, has no viability as such. However, convincing exit scenarios have been presented for both subgroups, which will merge into the future strategic themes “Physics of Energy” and “Physics of Life”.

In response to the draft report, the VU Executive Board asked to add the following reaction:

The VU Department of Physics decided in spring 2011 to discontinue the activities in Condensed Matter Physics in favour of a new research group “Physics and Chemistry of Energy”. The new research activity will have a strong interdisciplinary character. The new research group “Physics and Chemistry of Energy” will play a key role in the theme Science for Sustainability. We anticipate that the new research group will comprise two full professors and several positions at the level of assistant and associate professor, ensuring the long-term viability of this activity.

Programme VU 4: **Elementary Events in Biophysics**

Programme directors: Prof. R. van Grondelle, Prof. M.L. Groot, Dr. J.P. Dekker, Dr. J.T.M. Kennis, Dr. I.H.M. van Stokkum

Research staff 2009: 12.67 fte

Assessments:	Quality:	5
	Productivity:	5
	Relevance:	4.5
	Viability:	5

The programme aims at understanding the elementary events in biological reaction dynamics. This involves the study the transfer of excitations, electrons, protons in photosynthesis and enzymatics, the formation of a signalling state in photoreceptors, or how small molecular changes modulate the efficiency of photosynthesis (i.e. non-photochemical quenching). They use advanced spectroscopic tools and develop novel microscopic tools using nonlinear optical techniques to obtain images in deep-tissue with sub-cellular resolution.

The application of this line is in neurobiology and the study of larger scale phenomena in natural and artificial photosynthesis.

Quality

The group is one of the key players in the study of the early events in photosynthesis and has developed strong research lines in the fields of ultrafast biological reaction dynamics and biological photosensing, based on innovative laser experiments and state-of-the art data analysis.

The group is competitive on an international scale. The interests have migrated from photosynthesis to solar fuel, and this research will move to the Biophotonics group. The research group emphasizes five interrelated subjects:

(1) Primary Processes in Natural and Artificial Photosynthesis: Highlights include the discovery of the large-scale organization of the bacterial photosynthetic membrane; modelling the organization of the plant photosynthetic membrane; original studies of the oxygen-evolving reaction centre of Photosystem 2 charge separation; proof of a molecular mechanism for non-photochemical quenching, which is an important photoprotective regulation process in plants.

(2) Elementary Events in BioReaction Dynamics: This group has made the discovery that proton transfer can occur on a picosecond time scale, and that light-induced conformational changes in the enzyme POR determine catalytic activity. They have characterized the photocycle of photoactive yellow protein and of proteorhodopsin by multi-pulse spectroscopy. And they have found physical mechanisms that control the signalling state formation in photoactive yellow protein.

(3) Light-Driven Signalling: This group employs state-of-the-art transient absorption and emission spectroscopy and vibrational spectroscopic techniques, from ultrafast (fs) times to minutes. These experiments are conducted in the traditional, 'initiate-interrogate' way.

(4) Computational Biophysics

Time-resolved absorption and emission spectra are 2-dimensional data sets, the analysis of which in terms of physical models is mandatory. Software has been developed to perform the necessary manipulation of the data and is very successfully applied to a large number of experimental results.

(5) Biomedical photonics.

This program uses nonlinear optical techniques to obtain images in deep-tissue with sub-cellular resolution, with and without external contrast agents. Highlights include a deep tissue, label-free microscope for *in-vivo* applications, and demonstration of single-shot 2D OCT.

The group has developed a model for the dynamic reorganisation of the thylakoid membrane. A publication on brain slices in mice, which has relevance for Alzheimer research, has attracted much attention. A current focus is on determining the mechanism of optogenetic switches.

Productivity

Productivity in this group is high as measured by citations, papers, and the H-index, as well as productivity involving training throughput of students. The group has five tenured physicists, which is quite large. The number of PhD students is typically about 12 FTE, but in the past two years this has plunged to below 5 FTE

The group has attracted three Vidi award winners, who subsequently have been appointed as permanent staff members (Dr Kennis, Dr Groot and Dr. Frese, on tenure-track), and, recently, one Veni award winner (Dr Berera). The research programme is a major attractant for visitors within the framework of the EU-access.

Relevance

Group-trained postdoctoral fellows enter an academic career, or a career in government and industry. PhDs trained by this group find careers in science (postdocs), industry, medical institutions, government, education or sometimes elsewhere, but generally in knowledge-based jobs. VU-biophysics makes important contributions to the training of Master students in physics, laser sciences and medical natural sciences.

The group has made an important contribution to general understanding of the mechanisms of solar energy conversion and the important concepts of photosynthesis are applied in solar cell technology.

The work of this group is relevant to neurobiology and the study of macroscopic phenomena in photosynthesis. In addition, the insights about the primary events in biological reactions will elucidate the mechanisms and functions in enzymes. This could be of great importance in treating diseases.

Viability

The group is expanding; new staff is being hired, funds have been acquired. The expectations are that the group will grow to about 30 people. In that case, new facilities will be made available by the university, because the current building does not provide optimal space.

The succession of Van Grondelle in 5-6 years by talented staff in the current group is facilitated by his KNAW professorship.

VU is setting up novel laser-methodology to image fundamental processes in neurosciences, in close cooperation with the Technology Transfer office of the VU and the NCA.

Conclusion

The VU-Biophysics group combines high-level expertise in the study of ultrafast processes in biological systems. The study of the elementary events in photosynthesis is world-leading as

recognized by many prestigious awards to the members. The programme combines many innovative techniques, unique data-analysis and modelling theory. The staff has a combination of youth and experience. The laser-spectroscopic and biophysical expertise is now integrated into new microscopies, for neuroscience and membrane biophysics.

Programme VU 5: **Particle and Astroparticle Physics**

Programme directors: Prof. J.F.J. van den Brand, Prof. P.J. Mulders, Dr. H.J. Bulten, Dr. T. Ketel, Dr. G. Raven

Research staff 2009: 24.54 fte

Assessments:	Quality:	4.5
	Productivity:	4.5
	Relevance:	4.5
	Viability:	5

The aim of this programme is the understanding of the fundamental particles and forces of nature. The Standard Model of particle physics is used as the basic toolbox to account for the structure of hadrons and matter at the subatomic level. To go beyond the Standard Model and find the underlying concepts and structure, laboratory experiments are carried out at the highest energies or precision, and cosmological observations are used.

The programme contains three sub-groups:

- *Phenomenology in and beyond Standard Model*: the incorporation of hadron structure effects in high energy scattering processes focussing on spin effects and spin-momentum correlations of quarks and gluons; studies of the phase structure of Quantum Chromodynamics (QCD) and studies on masses and mixing patterns of neutrinos using symmetries among the different families of quarks and leptons.
- *Gravitational physics*: experiments on the emission of gravitational waves (GW) by accelerated bodies, with advanced detectors LIGO, Virgo, GEO600 and LCGT.
- *B-physics*: precise measurements of the properties of the charged weak interaction in the decays of b-hadrons.

Quality

The scientific activities and achievements of this research programme are internationally very well recognised and favourably compare to the top-10% of comparable research efforts and results world-wide. The visibility and impact of this group in several international large-scale experiments and communities is well pronounced. Although these achievements are obtained within the (larger) groups of Nikhef, the Committee acknowledged that VU scientists play a leading role in planning, designing, building and running the various projects at Nikhef, and thus significantly and actively add to – and clearly also profit from – the excellent infrastructure and scientific reputation of Nikhef. VU scientists had and still have leading positions and convenorships in projects like LHCb and VIRGO. Especially the VU LHCb group plays a significant role in this multinational endeavour. The technological contributions of VU scientists to these projects are excellent; they are important and well recognised pillars for their collaborative success. The Committee rates the overall quality of this research programme to be clearly leading, for the projects pursued, on the national scale, and to be clearly recognised and – in some cases – leading on the international scale.

Productivity

This programme produced a rather large number of publications in well recognised, international journals. This is especially true for the experimental papers, which are – in most cases – signed by rather large experimental collaborations of many authors. While this situation is typical for most experimental particle physics programmes, VU scientists did and do have a significant direct

impact on many of these publications, through their overall contribution to projects like Babar, and in fact made leading contributions to many of these analyses, some of them with leading impact to the field world-wide. Likewise, the publication record of the theory group compares well to other strong theory groups on an international scale. The Committee realised, however, that conference reports - and thus, presentations of projects at international conferences – are not reported for the experimental groups. Similarly, review articles or publications aimed at the general public are rather rare. This led the Committee to slightly downgrade the rating of productivity of this programme from “leading on an international scale”, which would be grade 5, to an actual grade of 4.5.

Relevance

The direct societal relevance of basic and knowledge-oriented research is normally very limited. In the case of this programme, significant technological advancements have been achieved in the field of developing particle detectors and related technological infrastructure. As typical in this field, however, such developments are not protected by patents, but are left open and available for all kinds of scientific and commercial uses. Education and technical as well as scientific training of large numbers of PhD students and post-docs, and the impact of this human capital on society and industry, makes the societal value of this field recognisable in many fields and aspects of life. The programme reports outreach activities and projects with industry, based on their technological developments for particle physics experiments. Altogether, the Committee regards the sum of these achievements, according to internally defined indicators, to be of very high international and leading national scale.

Viability

Future prospects of this programme are regarded to be of highest national and international standing, and are in fact excellent given the scientific importance, international standing and future relevance of these projects – LHCb as well as the gravitational wave projects. The programme is at the forefront of scientific research in both collider physics at the very highest energies, and in the physics of gravitational waves. The complementarity of these programmes ensures long-lasting viability in these fields, and offers very interesting future prospects also for students and young post-docs. The age structure of this group appeared to be very favourable and extends well into the future. The team gave a very motivated and dynamic impression to the Committee.

Conclusion

The overall impression of this programme is very good to excellent and of high international standing, comparing well to the top 10% of institutions in this field world-wide. The symbiosis with Nikhef and the concentration of basically two complementary programmes in particle and gravitational physics, together with the pronounced international networking, makes this programme a very attractive and fruitful part of basic research and student education in the Netherlands.

9A. INSTITUTE LEVEL - Utrecht University

University: Utrecht University
Faculty: Faculty of Science

1. The institute

In its current form, the Department was officially founded in 2006. The mission of the Department is to create a situation for its research staff to perform high quality research in pure and applied physics and astronomy. The research covers a broad spectrum of topics and is organized along nine programmes, three of which (History and Foundations of Science, Physics Education and Astrophysics) are not included in this review.

The Department of Physics and Astronomy is part of the Faculty of Science. The Dean has the integral responsibility for the Faculty of Science and is assisted by the Faculty Board. The Dean, the Vice-deans and the Faculty Director constitute the Faculty Executive Board. The Head of the Department of Physics and Astronomy is appointed by the Dean of the Faculty. The Head has the mandate to appoint temporary and technical personnel and to approve financial transactions up to 1 M€. A Board consisting of the Director of Education, the Director of Research and an advisory student member assist the Head of Department. The Departmental Committee is the consultative committee of the Department. The Committee consists of staff and students on the basis of equal representation.

Assessment/remarks

The Committee met with the Physics faculty, students and - at the Committee's request - with the Vice-Dean of the Faculty. At the time of the visit, morale appeared to be low in view of recent preliminary decisions taken by the administration to discontinue certain programmatic components. The Committee was confronted with re-profiling plans that were presented by the university administration just a few days before the visit, making the self-assessment report on which the review is based partly obsolete. The Committee expressed its concern about these re-profiling actions in a letter sent to the University Board immediately after the site-visits.

We must emphasise that at the time of the site-visit the re-profiling plans were not yet final and the discussion within the UU was still under way. The plan comprises an extensive reduction of permanent staff and accommodation and an increase of overhead to cover the costs of contract-funded projects. The resulting profile has to enable the Faculty to excel in the selected focal areas Molecular Life Sciences, Science for Sustainability and Foundations of Natural Science.

2. Quality and academic reputation

Research within the six programmes addresses many of the main questions in modern physics. Some highlights are:

- The *Nanophotonics* research programme created one of the largest Bose-Einstein condensate on Earth in 2006. This allowed the group to perform the first experiments ever on first and second sound, shock waves. Landau damping in BEC's opening the field of Bosonic transport and Atomtronics.
- The *Subatomic Physics* programme measured strong elliptic flow in heavy-ion collision within the STAR experiment at RHIC.
- The *Physics of Man* programme succeeded in adapting an experimental paradigm in vision.

- Using the method of Causal Dynamical Triangulation the *Theoretical Physics* programme has demonstrated for the first time that a macroscopic universe can emerge dynamically from pure quantum fluctuations.
- The *Soft Condensed Matter and Biophysics* group developed a colloidal model system of oppositely charged colloids, of which the long-range attractions can be tuned such that large ionic colloidal crystals are formed.
- The *Marine and Atmospheric Physics* group succeeded in reconstructing sea level and land-ice volume over the last 1-3 millions of years. Inferences could be made about the mid Pleistocene transition of dominant kyr cycles to 100 kyr ice-age cycles.

The Department's researchers have been awarded several distinguished prizes and have fulfilled international leadership roles in editorial activities.

Assessment/remarks

In retrospect, the majority of the programmes at Utrecht are internationally leading; they are of the highest quality, particularly in the area of solar nanophotonics which is slated to be discontinued at Utrecht.

3. Resources

Most of the services (finance, human resources, instruments, housing etc.) are organized at the level of the Faculty. The Faculty organizes Planning and Control (P&C) sessions with the Departments and Research Institutes on a yearly basis. The Department organizes P&C sessions with the programmes. The P&C cycle plays an important role in responding to new challenges, internal needs and changes in the external conditions. On an individual basis, all employees are evaluated through the result and development procedure (R&O).

The Department receives its funding from the University (direct funding). Most researchers receive their funding from a variety of external funding agencies. Of the entire budget of the Department in 2009 approximately 50% is financed by direct funding (the University), 40% by research grants (2nd stream financing) and 10% is based on contract research (3rd stream financing).

Assessment/remarks

Given the recent decision to discontinue part of the research programmes of the Physics department in Utrecht, the Committee finds it hard to comment on the adequateness of the resources. The consequences of this decision were not sufficiently clear to allow for an assessment of this aspect.

4. Productivity

According to the self-evaluation report the researchers of the institute mainly publish in peer-reviewed journals. The output is fairly stable across the review period with the exception of an unexplained peak in 2006. The average over the six years is 2.69 refereed articles per fte per year.

The number of PhD students who enrolled in 2000-2005 is 116, of which 85 graduated and 11 are still working on their thesis. The overall success rate was therefore 88% and the median duration 55 months.

The results of the CWTS-analysis show that the Utrecht programmes under review have produced 1567 articles in Web of Science journals in the 4 years of the review period. These

articles were cited 20 246 times, not counting self-citations. The mean citation score is 3.77 for Nanophotonics, 23.88 for Subatomic Physics, 5.13 for Physics of Man, 14.17 for Theoretical Physics, 14.12 for Soft Condensed Matter and Biophysics and 10.51 for Marine and Atmospheric Research. The highest number of papers among the 10% most frequently cited papers is 79 for Theoretical Physics. The number of refereed articles per full-time equivalent of academic staff in 2009 ranges from 1.17 (Soft Condensed Matter and Biophysics) to 5.16 (Subatomic Physics) in the programmes under review. The average for the Utrecht Institute in the period to be reviewed is 2.01. The average output per fte in all the programmes in this Physics review is 1.9.

Assessment/remarks

Productivity in all areas is excellent with areas such as soft condensed matter, theoretical physics and subatomic physics being truly outstanding.

5. Societal Relevance

The Department mentions the following evidence for the societal relevance of the research:

- participation of its researchers in the fourth assessment report of the Intergovernmental Panel of Climate Research. Outcomes of this report (2007) influence worldwide policies on reduction of carbon dioxide emissions;
- 4 patents within the area of nanotechnology;
- projects funded by NWO-STW, Senter–Novem (now Agentschap NL), FES and private sector funding.

Assessment/remarks

The societal relevance of the programmes on the whole is very high, particularly in the areas of solar nanophotonics and the “physics of man”, which are to be discontinued.

6. Strategy for the future

Within the next 5 years, the Department aims to maintain a state in which there are strong and well-funded programmes producing many high-impact publications, preserve the situation in which there are high-potential staff members strengthening the different research programmes and there are thriving PhD programmes which are well connected to the different research programmes (and to the MSc programmes).

Collaborations with six national research institutes and other universities help to achieve sufficient levels of broadness as well as focus and mass. Recently, the Department strengthened the ties with Nikhef by commitments related to the master programme in high-energy physics and additional funds for the Sectorplan position in high-energy physics. An important development is the establishment of the Delta Institute for Theoretical Physics, the collaboration between the theoretical physics institutes of Leiden, Amsterdam and Utrecht University.

Assessment/remarks

With regard to viability of the programmes the Committee is satisfied that they could be at a very high level with adequate administrative support. The Committee did not discuss any future strategies with the department, considering the recent financial developments within Utrecht University.

7. PhD Training

The training of PhD students is an important activity and objective of the Department. The training is carried out according to the rules of the Graduate School of Natural Sciences, the Graduate School of Life Sciences (both of the Faculty of Science) or, for some programmes,

according to the KNAW rules within one of the National Research Schools (Dutch Research School for Theoretical Physics; Helmholtz Research School). The educational programmes are aimed at broadening knowledge of the research field, training and development of academic skills (presentation/writing) and deepening of knowledge related to the PhD project through participation at summer schools and workshops. Attention is also paid to broader skills ranging from ethics to entrepreneurship, from understanding intellectual property to communication with the media. Nearly all PhD researchers attend an annual meeting within a research programme or a National Research School, where their academic skills and research capabilities are assessed. During these meetings, feedback is provided on the presentations and on the quality of the research presented. The Graduate School of Natural Sciences will play a more and more important role in the quality assessment of the PhD education in the coming years.

Assessment/remarks

The Committee met with a number of PhD students. They all said that they are quite satisfied with the support and supervision they get. They did not (yet) report about the benefits of the Graduate School; in most cases the PhD students follow their own trajectory and choose courses that are in line with their research subject. The research that the PhD students perform, forms an important part of the output of the Department. The success rate of the students is good.

9B. PROGRAMME LEVEL - Utrecht University

Programme UU 1: **Nanophotonics**
Programme director: Prof. R.E.I. Schropp
Research staff 2009: 13.83 fte

The programme focuses on nanophotonics, in particular the development of solar cells and the control of electrons and light-matter interaction at the nanoscale. This includes research into equilibrium and dynamic properties of opto-electronic devices and quantum matter. A broad spectrum from purely fundamental to application driven research is maintained within the programme. The mission of the Physics of Devices group is to be one of the leading groups in Europe and worldwide in growing, understanding and optimizing thin-film opto-electronic nanostructured materials that allow for competitive fabrication of large-scale solar panels. The mission of the Ultrafast Dynamics group is developing ultrafast photonic and plasmonic switching and ultrafast nano-acoustics and the study of collective quantum effects in high-density carrier plasmas in semiconductors. The mission of the Atom Optics group, being a world leader in harnessing quantum gases, is to study transport in bosonic gases and develops the field of Atomtronics.

General remark

The review committee was deeply impressed by the breadth and depth of the programme as a whole. The programme covers several fields of modern physics, ranging from fundamental investigations to applied science, from atomic and solid-state physics to solar-cell research, at a very high and internationally visible level, and a good combination of experimental and theoretical physics.

As the re-profiling actions have immediate consequences for the structure of the nanophotonics programme and the future of the individual research groups involved in the programme, the Committee decided to not score the programme as a whole but instead comment on the Quality, Productivity, Relevance and Viability of its three main research themes which might be formally disconnected in the future if the re-profiling becomes effective.

UU 1.1:	Physics of Devices	
Assessments:	Quality:	5
	Productivity:	4.5
	Relevance:	5
	Viability:	5

Quality:

The Physics of Devices group is studying some unique aspects of photovoltaics that stand out in the Netherlands and that might raise large international interest, specifically the study on robust photovoltaic devices with high efficiency. The work on amorphous silicon hot wire deposition techniques is of high standard. Amorphous silicon has an inherent instability due to sunlight. This is due to recombination induced bond breaking, known as the Staebler-Wronski effect. The work on plasmon coupled optics, where a very thin cell with a high internal field depletes the sensitive layer, is very promising and of great importance. In a nutshell, high efficiencies are achieved by trapping the light in a very small volume of material so that carriers never have to travel far.

Productivity:

The Physics of Devices group has an extensive capability for large-scale sample preparation and characterisation, and has industrial partners. It has and always had a large number of PhDs and very good external funding. In the research field of photovoltaic, the typical audience is not found in Nature or Physical Review Letters but in specialized journals and, most important, patents. Here the output of the Physics of Devices group is very significant. Output in the sense of machine capability and students is also very impressive.

Relevance:

A solution for stable and low-cost photovoltaic is not only of great importance to developing third-world countries but will almost certainly prove to be essential in maintaining a high standard of living in Europe. The Physics of Devices group has a good chance to provide such a solution. The direct output to industry is highly valued and protected by patents.

Viability:

The Physics of Devices group is extremely active and has very good productivity and ideas. There is no danger that by itself it is not viable. The group has significant income from third party research grants.

In the view of the review committee, the recent proposal by the university administration to terminate the group in the near future cannot be based on any of the four criteria quality, productivity, relevance, or viability. Moving this group will have major implications for its viability, since moving this kind of delicate equipment will not only be costly, but will also take a significant amount of time before it is running again, if it can succeed at all because knowledge will inevitably be lost during the move. Actually closing this group down in a responsible way is likely to cost significantly and thus reduce the university budget.

Conclusion:

The Physics of Devices group is a highly appraised group of high promise for Dutch economy and sustainability. The review committee thus recommends to cherish this group, give it proper support, and to let it grow further.

UU 1.2:	Atom Optics	
Assessments:	Quality:	5
	Productivity:	4
	Relevance:	4
	Viability:	5

Quality:

The Atom Optics group has established a convincing research programme at the frontiers of ultracold quantum gas research in general and Bose-Einstein condensation in particular. Specifically, the group has succeeded in making the largest condensate in the world, with the number of atoms in their condensate exceeding the number of atoms in other condensates by two orders of magnitude. With a combination of tricks, a condensate is produced with less sensitivity to disastrous avalanches triggered by three-body recombination. Highly elongated and nearly one-dimensional condensates are made as starting point to explore transport phenomena like first and second sound in quantum hydrodynamics. Promising first results have already been obtained and published in high-visibility research journals like Physical Review Letters. The atom optics group also collaborates intensively and very fruitful with the Institute of Theoretical Physics on various aspects of their experiments, as documented by joint publications.

Productivity:

Over the course of several years, the Atom Optics group has designed, built and improved a dedicated Bose-Einstein condensation machine which is unique in the world and which is running to specifications. Maintaining such complex and expensive apparatus requires dedicated resources. The addition of a smaller and technically less demanding experiment could add to the group's portfolio and make their research less dependent on a single machine.

Relevance:

The physics investigated by the Atom Optics group is highly topical and addresses fundamental problems of condensed-matter physics with a clean and controllable atomic system. It is inspiring for the progress in this and other areas of physics. In the future, the ability to produce an intense and diffraction limited beam of atoms might be relevant for the exploration of fundamental limits of atom lithography.

Viability:

The Atom Optics group has attracted enthusiastic and motivated PhD students to work on the experiment. The group has a clear vision concerning their future research. One can see that with such valuable team and such clear vision the group will find interesting new physics.

Conclusion:

The review committee recommends making every effort to keep the small but visible Atom Optics group in the department, further support their research by providing the resources which are necessary to compete with other groups worldwide in this rapidly changing field, and even give them the possibility to expand if they wish so.

UU 1.3:	Ultrafast Dynamics	
Assessments:	Quality:	4
	Productivity:	4
	Relevance:	4
	Viability:	4

Quality:

The Ultrafast Dynamics group investigates transient phenomena in condensed-matter systems, for example when laser generated electrons and holes are produced at such high density that screening effects become important and excitons do not easily form due to the then weak interaction between the electrons and the holes. In this regime the group investigates the possibility that the residual Coulomb attraction between electrons and holes leads to other forms of correlated systems. By studying the luminescence light emitted from the system, first results have been obtained in agreement with theoretical predictions. Beyond this example, the demonstration of novel quantum many-body phenomena in high-density and strongly correlated solid-state systems is highly topical and can only be mastered by a dedicated group with a demonstrated record of high-quality research.

Productivity:

The Ultrafast Dynamics group has successfully published in high-visibility journals like Physical Review Letters and competes with some of the best groups in the field worldwide.

Relevance:

The experimental findings of the Ultrafast Dynamics group will be of immediate interest to the community of condensed-matter physicists. Research with the kind of systems used by the group also complements very nicely the research with ultracold atomic quantum gases where experiments are typically performed in a different parameter regime.

Viability:

The Ultrafast Dynamics group's research programme has and will continue to produce interesting results. Experiments are on good track and new physics can be expected.

Conclusion:

The review committee recommends keeping the small Ultrafast Dynamics group in the department and continue to support their research by adequate resources.

Programme UU 2: **Soft Condensed Matter and Biophysics**

Programme director: Prof. A. van Blaaderen

Research staff 2009: 24.75 fte

Assessments:	Quality:	5
	Productivity:	5
	Relevance:	5
	Viability:	5

Soft Condensed Matter: The objective of this part of the Soft Condensed Matter and Biophysics programme is the use of new colloidal model systems to study fundamental (condensed matter) physics using experiments, theory, and simulations in a strongly synergistic approach. The focus is on the development and characterization of new model colloids for quantitative 3D real-space analysis using confocal microscopy and the manipulation of their self-assembly by external fields such as: corrugated walls, light, shear flow, gravity and electric fields. The ultimate goal of the research programme is to obtain a better understanding of fundamental (condensed matter) physics and to use this knowledge to make new advanced functional materials with special (mostly optical) properties such as photonic crystals, electro-rheological fluids, and electronic-ink.

Biophysics: This part of the Soft Condensed Matter and Biophysics programme is focused on the application and development of novel imaging methods. The mission of the group is to develop and exploit advanced optical microscopy. In the vision of the group the future of fluorescence microscopy lies in the combination of fluorescence imaging and spectroscopic techniques. The novel imaging methodologies utilize advanced light sources, non-linear excitation methods and contrast based on fluorescence spectroscopy.

Colloid science has a long and distinguished history in the Netherlands dating from the work of Van der Waals, Verwey and Overbeek. This group is a continuation of this tradition, but in the good sense. It is not simply a continuation because they have the tradition, but rather a leading continuation – they are defining what can be done and observed in these systems. Their embedding in the Debye Institute, which brings together the physics of colloids (this group) with colloid chemistry, makes for an even stronger and world leading programme in colloid science.

Quality

This is definitely a top programme in soft condensed matter on an international scale. The group uses innovative synthetic techniques to make colloidal particles of specified size, shape and interaction to control the self-assembly properties of the colloidal structures formed. Focus is both on using colloids as models for atomic systems and as systems in their own right who's self-assembly properties can be exploited to make novel materials and devices. Output is excellent and leads the field of colloid science. Papers appear in the top journals in the field as well as in Nature, PRL, etc.

Productivity

The number of publications in the top journals in the field is very high. Considering the size of the group the Committee assesses the productivity as excellent.

Relevance

There are many applications in industry for this research. Most personal care products – shampoo, laundry detergent, paints, coatings, food stuffs, etc. – are colloids and their properties are dictated by the interactions of the discreet elements and the associated flow of these

materials. This group is a world leader in synthesizing, characterizing, and controlling colloidal dispersions. The group's interactions with industry are very good. The work has resulted in several patents.

Viability

The group has active collaboration through the Debye Institute with colloid chemists and access to students and postdocs with a synthesis background. This enables them to design and make colloids to test important physical processes. It also provides a strong educational component for students who are trained more broadly in colloid science that is typical in most physics programmes. The work and students are in demand in industry thus assuring their relevance and continued success.

The biophysics programme is less well defined and does not enjoy the same international recognition and impact as the colloids programme. The work is motivated by instrument development, rather than from pressing physical questions. There are potential benefits from a closer connection and collaboration between colloidal physics and biophysics, and the group has recently hired a new assistant professor in biophysics who will help bring the groups together.

Conclusion

This is one of the strongest groups in Physics Research in the Netherlands that combines synthesis, experiment and theory (largely MD and Monte Carlo) to understand colloidal properties.

Programme UU 3: **Marine and Atmospheric Research**
Programme director: Prof. W.P.M. de Ruijter
Research staff 2009: 28.13 fte

Assessments: Quality: 4.5
 Productivity: 4.5
 Relevance: 5
 Viability: 5

The primary mission of the research programme Marine and Atmospheric Research is to improve the fundamental understanding of the climate system, with special emphasis on the components atmosphere, ocean and cryosphere, how they interact and how and why they change.

The research of this programme comprises five themes:

Ocean Circulation and Climate: The main focus within this theme is on the characterization of the present-day ocean circulation through observations and modelling, the understanding of the physical processes involved in this circulation and to study the role of the ocean circulation in the global climate system.

Atmospheric Physics and Chemistry: In this theme, research is carried out on the chemical composition of the atmosphere, the change in this composition due to anthropogenic emissions and the interactions of atmospheric chemistry with the Earth's climate. Measurements, both in the atmosphere and in the laboratory, and computer models are used to achieve that goal.

Physical Oceanography of the Coastal Zone: In this research theme, focus is on the physics of water motion, transport of sediment and bottom pattern formation in coastal seas and estuaries, and to assess the response of the coastal system to anthropogenically-induced changes. The research approach involves collection of field data and developing process-based idealized semi-analytical and numerical models.

Atmospheric Dynamics and the Hydrological Cycle: Focus in this research theme is on the water cycle, including phase transitions of water as well as the interaction of water with radiation, and how it interacts with the dynamics of the atmosphere. To that end, a mix of observations, (regional) climate models and conceptual models is used.

Ice and Climate: The interaction of land ice with climate in the past, present and future is the central focus of this research theme. To that end, a combination of observational (remote sensing, autonomous weather stations and GPS receivers) and modelling techniques (regional climate models, conceptual and full 3D ice sheet models) is used

Quality

This programme covers a rather broad field. The researchers included have identified and formed important niches and most of them are world-leading and have recently contributed several seminal papers in leading journals.

The GPS-based ice velocity measurements have enabled to uncover rapid and large fluctuations which have strong implications on the influence of the feedback between melt rate and ice velocity and these records are used as the benchmark for glacier melt models; based on the regional climate model for Antarctic and Greenland RACMO2 a substantial improvement of the

mass balance estimates of ice sheets was reached; they are also leading in modelling atlantic multidecadal oscillations and their implications to extreme events in Europe and North America, in their experimental expertise in isotope analysis and studying the global methane cycle, especially methane emission, and its importance for the tropospheric and stratospheric chemistry, and in modelling tidal inlet systems.

Several groups benefit strongly from the intimate interaction with KNMI, e.g. use of their large models.

The impact of the publications is very good as reflected in the MNCS of 1.34.

Productivity

The researchers have a very good publication record in leading journals of the field (GRL, JGR etc.), but also in highly prestigious review journals (Ann. Rev. Fluid Mechanics, Rev. Geophys.) as well as with 8 papers in Nature and Science.

Relevance

The topics of the past and future work of these groups focus on problems of very high relevance for the society, e.g. melting of ice, dynamics of the tidal system and their impact on the sea-level, new land surface schemes for the ECMWF or impacts of climate changes for the formation of extreme events. The research contributed significantly to these topics and is expected to be able to do so in the future as well, both from a scientific and from a societal point of view.

Viability

The researchers are key players in international programmes on marine and atmospheric research. They also efficiently interact with related Dutch organizations, especially KNMI, BBOS, NIOZ, CKO and NCK. The groups have focused their main topics and it is very important to emphasize that they will develop remote sensing as a very promising joint umbrella of their future research activities; this could substantially increase their visibility as one unit.

Conclusion

The groups of this programme have developed a broad and innovative research portfolio which is internationally highly visible. The review committee strongly recommends to give this group proper support and to let it develop further.

Programme UU 4: **Theoretical Physics**
Programme director: Prof. H.T.C. Stoof
Research staff 2009: 40.57 fte

Assessments: Quality: 5
 Productivity: 5
 Relevance: 4
 Viability: 4

The programme has been developed along two parallel lines of research, namely, Quantum Gravity, Strings and Elementary Particles, and Soft Condensed Matter.

The first theme aims at understanding and describing the elementary constituents of matter and their interactions, as well as their implications for cosmology. It pertains to very small-scale physical phenomena, from the subnuclear to the Planck scale, as well as their implications for physics at the very large scales that are relevant for cosmology.

The central goal of the theme ‘Condensed-Matter Theory, Statistical and Computational Physics’ is to obtain a detailed understanding of the collective behaviour of many-particle systems from a fully microscopic point of view. Research topics include the quantum Hall effect, superconductivity and superfluidity, Bose-Einstein condensation, quantum magnetism and spintronics, polymer dynamics, as well as the phase structure and dynamics of liquid dispersions and colloidal suspensions.

Quality

This group includes some very well-known senior figures, e.g. ‘t Hooft – Nobel 1999, De Wit – ERC Advanced Investigator Grant, as well as some brilliant younger scientists, e.g., Duine – ERC Starting Grant, van Rooij, and Stoof, who is also an impressive and effective group leader. The group has for many years been regarded as one of the leading theoretical physics groups in Europe, at least in the fields in which it is active. Academic reputation is manifested by the large number of applicants for postdoctoral positions and participants in their Masters programme. It is not clear how much communication goes on between Elementary Particles and Quantum Matter, with the possible exception of ongoing developments using the AdS/CFT approach. The citation score of this group, MNCS, is above 2, higher than national average (1.8) and much higher than world average (1.0).

Productivity

This is a very productive group. It is encouraging that the quantum gravity and particles group is embarking on a joint project with the subatomic group on applications of the AdS/CFT correspondence to quark-gluon matter: it will be good to see a similar initiative in condensed matter physics.

Relevance

Theoretical physics is attractive to prospective physics students, many of whom then move into other areas of physics. It is therefore highly relevant to scientific education, and ‘t Hooft has been particularly active in this regard. New theoretical breakthroughs in fundamental physics eventually have wider applications, cf. Maxwell and Einstein in the past, though these may take decades to emerge. It is therefore unreasonable to expect immediately visible spin-offs from this type of research, but the quality and productivity of this group gives reason to expect that these will emerge in due time. Condensed matter theory has more immediate potential applications to

devices, and also provides an important source of inspiring toy problems that give insight into more realistic problems.

Viability

The group sees its limited faculty as a structural weakness, and would benefit from new recruitments to maintain its reputation as older stars retire. The quantum gravity and particle physics group has recently extended its activities to include cosmology, and has embarked on a joint project with subatomic physics. It, in particular, needs to consider how to replace the retiring senior members of the group. The condensed-matter group has extended its activities to include soft matter, and seems quite vital, mostly following analytical approaches, but also extending to simulations. To protect the diversity of research lines within the group, decisions about future developments should be encouraged through a bottom-up democratic approach.

Conclusion

This group is one of the jewels of physics in Utrecht, and indeed in the Netherlands as a whole, with an enviable international reputation for quality and originality. A brilliant younger generation has now taken the scientific leadership over from the stellar previous generation, and is making every effort to maintain and build upon the group's reputation, e.g. by extending its activities into cosmology, collaboration with subatomic physics group and research in soft condensed matter. In this respect, the group needs reassurance that it has full support from the university administration, in particular for key new recruitments.

Programme UU 5: **Physics of Man**
Programme director: Prof. C.J. Erkelens
Research staff 2009: 5.48 fte

Assessments: Quality: 4
 Productivity: 4
 Relevance: 5
 Viability: 5

The mission of the group is to arrive at an understanding of human consciousness based on empirical and theoretical studies of human perception in relation to the physics of the natural environment at the scales of human–environment interactions. Internationally this field would be designated “cognitive science”, but this field is not recognized as an independent discipline in the Netherlands. It is an intrinsically multidisciplinary field involving physics (of the human environment, which is necessary to understand what is out there to perceive), neuroscience, experimental psychology, and computer science (machine vision, robotics).

The programme addresses a number of topics that vary over the years and that are related because of the common interest to further our understanding of human perception and behaviour. The studies involve psychophysics as well as electroencephalography and functional magnetic resonance imaging. Major topics of the past few years are haptic perception of shape, space and material properties, binocular vision and eye movements.

Quality

The researchers in this group have a long-standing expertise in visual perception and have especially made substantial and highly recognized contributions to the control of eye coordination both in experiments as well as modelling. The group performs original work on haptic research by developing interesting experimental paradigms. In this research area the group is international leader. The researchers have induced various research activities.

The analysis of the experimental (haptic) data is thoroughly done, but the techniques are rather standard (correlation analysis etc.). In the view of the Committee the modelling method the group uses is interesting, but it is no breakthrough. The impact of the research is high, the publications of the group are well cited, when the size of the field, i.e. the number of researchers who can refer to the work, has been taken into regard.

Productivity

For such a small group they have published a large number of papers in good peer-reviewed journals. The group has a considerable number of PhD students; whose success rates are improving. The group is very active in editorial boards, committees and conferences.

Relevance

The studies on haptic perception have opened new fields of applications which could prove to be of great importance, not only as a completely new approach to performing remote surgery, but also for robotics (e.g. FP7-ICT project). There are even great opportunities in gaming.

Viability

The size of the group is critical. They do not have strong scientific interactions with other parts of the institute. The recent change of the main focus to haptic perception, which is a very promising field, is according to the Committee very positive. Furthermore the researchers have a

clear vision how to develop this interdisciplinary field including very important direct applications in medicine and robotics.

Conclusion

The review committee strongly recommend that this small and very active group should get adequate resources such that it can continue its very promising activities at UU (maybe in an institute of the life science faculty). It is of high relevance for applications in modern medicine as well as in robotics.

Programme UU 6: **Subatomic Physics**
Programme director: Prof. Th. Peitzmann
Research staff 2009: 9.69 fte

Assessments: Quality: 5
 Productivity: 5
 Relevance: 4
 Viability: 5

The mission of the group is to contribute experimentally to the fundamental understanding of the collective behaviour of elementary particles via the ultra-relativistic collisions of nuclei. Conventional nuclear matter is expected theoretically to manifest quark and gluon degrees of freedom at high energy densities, as a quark-gluon plasma, whereas experiments have shown that it behaves as an almost perfect liquid. The group explores the properties of quark-gluon matter in high-energy nuclear collisions, formerly in the STAR experiment at Brookhaven National Laboratory in the US and now in the ALICE experiment at CERN. The main research topics of the group are elliptic flow - which probes the equation of state of the matter produced in the collisions, and notably its remarkably low viscosity, jet quenching and heavy-quark production - which measure the stopping power of quark-gluon matter, and in the future also forward particle production - which probes the saturation effects expected for gluons carrying small fractions of the energies of the colliding nuclei.

Quality

Internationally, research in this field of fundamental physics is conducted in large global collaborations involving hundreds of scientists, performing unique experiments. This group participates successfully in such collaborations, being recognized as punching significantly above its weight. It is providing leadership within this international effort, e.g., in building key experimental hardware for the ALICE experiment and in spearheading crucial data analyses for the previous STAR experiment as well as ALICE. The first ALICE publication on heavy-ion collisions was based on this group's analysis of elliptic flow, and the group is now leading an analysis of higher flow components. The group has recently started a research collaboration with theoretical physicists in Utrecht on the AdS/CFT correspondence, which is a promising way to interpret the flow results.

Productivity

The group was very productive in its previous STAR collaboration at Brookhaven, contributing principally via analysis projects it led. The detector construction work for ALICE did not lead directly to many publications, but made possible the experimental programme that is now producing many publications, notably those based on analyses led by the UU group. It is entering a very productive phase of exploitation of ALICE, which is likely to continue for a decade or more, with increasing data rates, increasing energy and a variety of colliding nuclear species.

Relevance

This field grabs the attention of society at large, and young people in particular. It is therefore a key attractor for prospective physics students, most of who later move into other areas of physics. Many prospective employers outside academia are interested in the skills acquired by PhD students in this field, such as data analysis combined with modelling and the experience of working in highly competitive international collaborations.

Viability

In addition to playing a leading role in key ALICE analyses, the group is providing coordination

for the ALICE upgrade plans. Its new collaboration with the theoretical physics group on the AdS/CFT interpretation of flow measurements is very promising. The ALICE experiment has a decade or more of productive physics ahead, and the Utrecht group is well embedded nationally in collaboration with a group at NIKHEF, which is well organized and funded.

Conclusion

This group is one of the strongest university experimental groups working in this competitive international field, making important contributions to a wide range of activities including both hardware construction and data analysis, which are appreciated enthusiastically by the ALICE collaboration. Within the Netherlands, the group collaborates effectively with the experimental heavy-ion collision group at NIKHEF, and is starting a promising collaboration with the Utrecht theoretical physics group. The group has a strong research programme for the foreseeable future that is interesting and attractive.

10A. INSTITUTE LEVEL - Delft University of Technology

University: Delft University of Technology
Faculty: Faculty of Applied Sciences

1. The institute

Research and education in the discipline Applied Physics at Delft University of Technology (TU Delft) is embedded in the Faculty of Applied Sciences. Applied Physics aims at both fundamental understanding of physical phenomena and their practical use. A broad spectrum of subjects is covered, ranging from quantum information technology to the mechanics of DNA. The research is performed within organizational units, departments, each designed to have a common intellectual mission.

The applied physics programmes are carried out by the Departments of Bionanoscience (BN), Imaging Science & Technology (IST), Multi-Scale Physics (MSP), Quantum Nanoscience (QN) and Radiation, Radionuclides & Reactors (R3).

The Faculty's management team consists of the dean, the heads of departments, the director of education and the executive secretary of the Faculty. The dean of the Faculty has the final responsibility for research, education and management.

Assessment/remarks

The general impression of the Committee in assessing the programmes, meeting the faculty and students, and the administration including the Rector and Dean of the Faculty was very positive. The level of enthusiasm for research and the level of administrative support were very high. The Committee could see why TU Delft had such a high reputation internationally in applied science.

2. Quality and academic reputation

In recent years interdisciplinary cooperation with medical sciences, chemistry and molecular biology has been started or strengthened. For medical physics collaboration has been set-up in the region, called 'Medical delta', which led to joint research programmes with the medical faculties of the University Leiden and the Erasmus University Rotterdam. For molecular biology a new Department Bionanoscience is created, which consists of a mixture of physics and biology. The interaction with chemistry takes place in the research programmes that rely on process technology and advanced functional materials. An important development in the profile of the institute was the incorporation of the Reactor Institute Delft and the Department Radiation, Radionuclides & Reactors in 2005.

Researchers of the institute are involved in many collaborations. TU Delft has strong ties to the other two universities of technology in the Netherlands (3TU Federation). The Applied Physics programmes participate in the following 3TU Centres of Competence: Application of Nanotechnology, Fluids and Solid Mechanics and Sustainable Energy Technologies.

The Reactor Institute Delft participates in the planned European Spallation Source. The institute was also designated one of the world's thirteen Collaborating Centres of the International Atomic Energy Agency (IAEA).

The Departments of Bionanoscience and Quantum Nanoscience were elected to form the Kavli Institute Delft, which is the only founding Kavli institute of Nanoscience outside the US. Delft heads the National research Platform for Sustainable Energy (NODE) which is a forum for

Dutch researchers in sustainable energy generation and energy transport.

Delft leads the European Union Cloud Intercomparison, Process Study & Evaluation Project (EUCLIPSE) to study the role of clouds in contributing to climate change.

Assessment/remarks

Academic reputation and productivity of the programmes are excellent. The two nanoscience-related programmes are internationally leading, while the other three, which have a somewhat more applied agenda, are internationally competitive.

3. Resources

Human Resources policy is aimed at stimulating the scientists to build their own individual scientific reputation, while at the same time contributing to the strength of the research group. New staff members are primarily selected on their excellence in research as the department has no fixed chairs. Researchers are actively stimulated to apply for personal grants (ERC grants and the NWO Innovation programme. Yearly evaluation (appraisal and assessment) cycles for the staff members are defined and supervised on the institute's level.

The share of direct funding has decreased in the last two years of the evaluation period and the share of research funding and contracts is strongly varying. The institute saw a strong increase of Research funding in 2008 which is caused by the so called Smart mix programme, an initiative of the Dutch government in which the TU Delft participates.

Assessment/remarks

The Committee had a guided tour during the site visit and could establish that research facilities in Delft are very good. The Human Resources policy seems to be very supportive for the researchers; the Committee did not encounter any problems and did not hear from any obstacles for the researchers.

4. Productivity

The institute aims to disseminate scientific results through recognized refereed journals with a high impact factor. Scientists are encouraged to publish their results in the top journals of their field. In some research areas, dissemination of research results through peer reviewed conference proceedings is also important as well as generating patents.

The results of the CWTS-analysis show that the Delft programmes under review have produced 1687 articles in Web of Science journals in the 4 years of the review period. These articles were cited 22 110 times, not counting self-citations. The mean citation score is 32.38 for Bionanoscience, 6.64 for Imaging Science & Technology, 5.27 for Multi-scale Physics, 22.13 for Quantum Nanoscience and 6.19 for Radiation Physics for Energy and Health. The number of refereed articles per full-time equivalent of academic staff ranges in 2009 from 0.99 (Bionanoscience) to 1.70 (Multi-scale Physics and Radiation Physics for Energy and Health in the programmes under review. When taking the conference proceedings into account the number of publications ranges from 0.99 (Bionanoscience) to 2.67 (Imaging Science & Technology). The average output for the Delft programmes in the period to be reviewed is 1.21. The average output per fte in all the programmes in this Physics review is 1.90.

Assessment/remarks

The productivity of the programmes is aligned with their quality, the two related to nanoscience being at the highest level. The others are somewhat lower but still excellent. The difference might arise out of the more applied nature of the programmes centred around imaging science, multi-

scale physics and radiation science and technology which publish less but have naturally have more emphasis on applications of direct benefit to society which have more intangible measures of productivity than publication

5. Societal Relevance

The industrial relevance is illustrated by the following:

- The institute is involved in a wide range of collaborations with industry. Key industrial partners are Shell, Philips, NXP, FEI Company, ASML, KLA Tencor, Unilever, Zeiss, Tata Steel, Petrobras, Frames, Krohne.
- Delft physicists participate in many public-private partnerships, such as Nanoned, CYTTRON, *Pieken in de Delta* and others.
- In total 124 patents were filed during the past 6 years.

The Faculty is involved in the development of instruments with important applications in other research areas. Delft researchers often comment on (inter)national developments in the Dutch media.

Assessment/remarks

The more “applied” programmes are at the highest level of societal relevance, except for Multi-Scale Physics, which is on par with the more fundamentally-oriented nanoscience programmes as being highly relevant.

6. Strategy for the future

The institute describes its strategy for the future in three main topics:

1. The institute aims at further interdisciplinary cooperation between the research groups in particular on health, energy and nanomaterials. The new faculty building will unite the departments of Biotechnology, Chemical Engineering, and Bionanoscience and will provide the opportunity to strengthen this collaboration. It will also provide state-of-the-art infrastructure.
2. The Faculty will encourage and support further growth of the new Department of Bionanoscience at the interface between nanophysics and biology. The department will also lead to a further strengthening of cooperation with other biology and biophysics groups of the University Leiden and Erasmus University Rotterdam.
3. The connections with Leiden University and Erasmus University Rotterdam will be exploited, partly through already existing projects like Medical Delta and NeCEN and partly by facility sharing and more cooperation on new research initiatives like sustainable energy and health.

Assessment/remarks

With regard to vitality and feasibility, all programmes have, and have had, strong administrative support that has enabled them to successfully develop and implement strategies to take their research forward. Multi-scale physics is being disbanded, but the components are being placed in operating units which will provide them with supportive environments. While this reorganization is very recent, we examined its potential impact on the viability of the research components of the programme and concluded that great care had been taken to enable their survival and improvement.

7. PhD Training

At the moment of writing of the self evaluation report 217 PhD students were enrolled in the PhD programme. The PhD students have an Education & Supervision Plan from the first year onwards which is updated yearly as part of the Result & Development cycle.

The main task of PhD students is to perform research that leads to conference contributions, refereed journal papers and a PhD thesis in 4 years. As part of the training programme PhD students are offered a comprehensive set of courses. Students have to follow courses directly related to their research field as well as generic trainings aimed at acquiring competences and transferable skills. The generic courses prepare the students for their future career which is for most PhD students in academic research. Courses are offered by the TU Delft and the national research schools. The educational plan is tailored to the needs of every PhD student.

Quantum NanoScience and Bionanoscience have organised their PhD training in the Delft-Leiden Casimir Research School. The PhD students benefit from the collaboration between Delft and Leiden and the allocated 4 years are rarely exceeded.

Assessment/remarks

The Committee met with the PhD students and saw very enthusiastic young excellent researchers, who are dedicated to their subject. The supervision and training of the students is very good and fit to the needs of the students. The success rate of the PhD students is very good.

10B. PROGRAMME LEVEL - Delft University of Technology

Programme TUD 1: **Bionanoscience**
Programme director: Prof. C. Dekker
Research staff 2009: 21.2 fte

Assessments:	Quality:	5
	Productivity:	5
	Relevance:	4
	Viability:	5

The mission of the group is understanding and engineering biology at the nanoscale. The evaluation period concerns the research of the Molecular Biophysics group (MB), which has focused on single-molecule biophysics. The group, started only as of on 1 January 2010 at the initiative of C Dekker and N.H. Dekker, previously in Delft's Molecular Biophysics, developed into an entire new department at the interface between nanophysics and biology. The research portfolio of Bionanoscience spans the range from molecular, cellular and synthetic biology on the one end, to biophysics, nanopores and microscopy development on the other. The unifying theme is the fundamental exploration and engineering of the biological cell.

Quality

The quality of the research done in this group is excellent. The group is internationally highly visible and world leading in a relative new research area. The academic reputation of the leading researchers in this group is excellent. Based on their top level experimental equipment and approach they were first to perform force measurements on DNA in a nanopore and reached further similar breakthroughs in measurement techniques. The group also initiated research into the understanding of basic mechanisms in bionanoscience, especially to repair DNA or on bacterial growth in sub-micron size pores.

The impact of the results is among the highest worldwide, the MNCS (Mean Normalized Citation Score) is according to the Bibliometrical Analysis of CWTS 3,41 and the AE Ptop⁴ is 4.60. The professors obtained many grants and prizes for their work.

Productivity

The group has an outstanding publication record in journals of highest reputation, such as Nature, Science, PNAS. The group is successful in acquiring research funds and the researchers involved are very actively involved in academic communities and in public outreach.

Relevance

This research could have important perspectives in applications, but it has been so far more fundamental. The leading researchers already got some patents and they have several contacts with industrial partners on nanopore sequencing and related techniques as well as with hospitals. These activities should be strengthened.

Viability

The group has developed a very ambitious research programme focused on highly promising topics. Its intimate interrelation with the Kavli Institute at TUD ensures an outstanding research

⁴ The actual number of papers among the 10% most frequently cited compared to the expected number of papers in these top percentiles based on the total volume of papers.

environment. The envisaged expansion of this programme is crucial for reaching the ambitious goals.

Conclusion

The review committee highly recommends to proper support the further development of this excellent group. The group should continue its outstanding research on fundamentals of bionanoscience, but it should stronger develop also relations to industrial partners and to medical applications.

Programme TUD 2: **Imaging Science & Technology**

Programme director: Prof. L.J. Van Vliet

Research staff 2009: 56.1 fte

Assessments:	Quality:	4
	Productivity:	5
	Relevance:	5
	Viability:	5

The mission of the group is to advance the fundamental understanding of physical phenomena leading to new innovative imaging principles and novel imaging instruments. The group is active in four research areas. In the area of Acoustical Imaging the focus is on full 3D wave field propagation in inhomogeneous media and nonlinear inversion techniques. In the area of Charged Particle Optics the aim at the instrumentation chain from electron/ ion sources, via system design to beam-sample interaction. In the area Optics the fundamental phenomena in the field of diffraction and scattering of light by sub-wavelength structures, wave propagation and imaging at wavelengths ranging from EUV to the far-infrared are theoretically and experimentally studied. In the area of Quantitative Imaging image-based measurement principles based on computational imaging and algorithms for digital image processing for applications in life sciences and health are invented.

Quality

A wide variety of subjects are treated by the Imaging Science and Technology group, mainly applied research with immediate impact on society and economy. The main idea is to further develop innovative imaging principles and new imaging instruments based on light, acoustics, and charged particles. Applications range from seismic and medical imaging to nanotechnology, from the very large to the very small.

Research highlights include, for example in acoustic imaging, the demonstration of new imaging methods for the petrochemical industry. This work is performed in the context of the Delphi consortium which involves an impressively large number of industrial partners, and this for almost 20 years. The acoustic work finds further applications in medicine and non-destructive testing.

The group has also been very successful in the area of imaging via multi-beam electron sources. This kind of work is important for the semiconductor manufacturing industry, as documented by the fact that the Mapper Company has its origins in the laboratories of the Imaging Science and Technology group. The imaging technique has now been extended towards the deposition of metallic materials via electron beam induced deposition, a technique enabling the direct printing of extremely fine structures.

Last but not least, with the incorporation of classical optics and quantitative imaging in a variety of technologies, the group has an impressive and broad pallet for industrial and medical applications coming out of academic research. Several aspects of the group's research are unique worldwide.

Productivity

A high output of industrially relevant publications and patents has been produced by the Imaging Science and Technology group in the reporting period. In the view of the review committee this production is more relevant than the publication production of some 80 articles per year with a

citation score of 1.4. In particular, judgement of the success of the group cannot be based on simply counting the number of publications in journals like Nature and Science.

Relevance

The Imaging Science and Technology group is very clearly a highly relevant group for society in the form of medical solutions, industrial developments and in general solutions for societal problems. The group has broad ties with industry, a number of remarkable start-ups and attracts high student interest.

Viability

The Imaging Science and Technology group offers a stimulating climate for collaborative research and for the education of students in modern aspects of imaging sciences. Recent reorganizations have led to a viable and productive environment that is likely to produce many well trained and motivated physicists.

Conclusion:

The broad and innovative research portfolio and the large number of industrial partners of the Imaging Science and Technology group is something the university can be proud of.

Programme TUD 3: **Multi-Scale Physics**
Programme director: Prof. H.E.A. van den Akker
Research staff 2009: 25.9 fte

Assessments:	Quality:	4
	Productivity:	4
	Relevance:	4
	Viability:	4

The mission of the group is to contribute to the science of transport phenomena with emphasis on fluid mechanics problems, often as described by the Navier-Stokes equations and various scalar transport equations. The programme attempts to reduce empiricisms in the description of flow and transport processes, particularly under turbulent and multi-phase flow conditions. The approach follows the great tradition started and developed many decades ago in this (the Kramers) laboratory that led to the unified study of mass, momentum and heat transfer providing a sound theoretical basis for the unit operations of chemical and process engineering.

The research themes within the programme are: clouds & climate; computational reactor engineering; multi-phase flows; reactive flows; and thermal & materials processes.

Quality

The programme is of very good quality with results being published in leading to good journals in the field. There appears to be something of a lag between the research results discussed below being obtained and then published in refereed journals, so we have taken account of conference papers and dissertations as well in assessing quality. The programme is divided into a number of subprogrammes, each separately meriting a '4'. In more detail, the 'clouds and climate' group is highly regarded for research on the formation and dynamics of clouds; particularly, massively parallel computations of interactions between turbulence, cloud processes and precipitation that are state of the art. The work on 'computational reactor engineering' emphasizes innovative lattice-Boltzmann, direct and large-eddy, simulations that are being successfully applied to large-scale chemical reactors. These are now being extended to the very difficult problem of gas-liquid micro-reactors, where surface-fluid interactions play a major role. For 'multiphase flows' sophisticated experiments and numerical simulations have been brought to bear on industrially important systems, notably bubble columns and fluidized beds, investigating vortical (cell-like) structures that significantly affect system behaviour. The programme on 'reactive flows' is also internationally recognized, leveraging cutting-edge numerical and experimental methods, such as CARS to measure temperatures non-intrusively. The 'thermal and materials processes' group covers several areas ranging from chemical vapour deposition of thin films, through microfluidics technology with promising biomedical applications, to study of magnetohydrodynamic effects with diverse application from metallurgy to drug targeting. An important aspect of the programme is that it incorporates large-scale (macro) facilities that allow scale-up issues in process technology and fluid mechanics to be addressed.

The wide range of applications cited demonstrates the versatility of the approaches followed, which leverage recent developments and indicates a leading national programme. Further, several PhD students have gone on to faculty positions which is also an indicator of high quality. To rise to leading international status, it would be necessary to focus and progress towards resolving one or more really significant issues in the field whether of intrinsic or applied importance. The MSP programme is being re-profiled to subdivide it, incorporating appropriate subprogrammes in Chemical Engineering, Mechanical Engineering and the Climate Institute. The components will perhaps then be placed in environments that might lead to truly international stature by fostering

collaborations and achieving critical mass for each activity. In arriving at the retrospective assessment for quality, no consideration has been given to the possibly deleterious effects of retirements or separations that have occurred, at least one of which was for an international, and difficult-to-replace, figure in turbulence.

Productivity

The level of publication in refereed journals is very good and has stayed reasonably level over the review period, as has the number of PhD students. The students take somewhat longer than the preferred period of 4 years, which might be a reflection of the large-scale experiments and simulations conducted in some cases. This is a productive group that is at the national forefront in its field. A significant number of refereed journal articles particularly in the early part of the period under review, but continuing till the end of the period, emanated from a now retired, very productive and eminent, faculty member (Hanjalic). In conducting this retrospective assessment of productivity we have not taken the potential effect of this retirement into account, and have only gone by the record.

Relevance

Interactions with industry and external agencies in areas of significant relevance to society such as sustainability and the environment are very good, but again not exceptional by international standards. There are apparently no patents, intellectual property licensing arrangements or spinoff companies in the assessment period. However, there are excellent collaborations with industry, national and European agencies, which merits the 'very good' in our assessment.

Viability

The programme is being reorganized with certain components moving to the Climate Institute and others to Chemical Engineering and Mechanical Engineering. The research components will continue in these settings. However, not any longer being a part of Applied Physics, they may receive a significantly lower intake of PhD students from Applied Physics. As 50% of PhD students in the programme are from Physics this would constitute a potentially significant issue in the viability of components of the current programme. Coupled to this are separations and retirements, which to some extent have been compensated for by hiring of new tenure-track faculty, two new part-time faculty from industry and government, and a part-time faculty member from Princeton. In addition the area sector plan calls for possible faculty appointments in the future. In sum, the viability of the programme while not excellent is sufficient to merit a 'very good'.

Conclusion

This is a very good programme that is nationally leading in the area of fluid mechanics and transport phenomena and internationally competitive, but not internationally leading. Perhaps as indicated in the self-assessment, the projects being undertaken are too diverse and widely spread to have a groundbreaking impact, but nonetheless they are of very high overall standard.

Programme TUD 4: **Quantum Nanoscience**
Programme director: Prof. H.S.J. van der Zant
Research staff 2009: 103.5fte

Assessments: Quality: 5
 Productivity: 5
 Relevance: 4.5
 Viability: 5

The mission of the group is to advance the understanding of physical processes at the nanoscale, with a focus on research for fundamental scientific and technological breakthroughs. Its broad goal can be stated as Quantum Machines. The approach is based on quantum engineering, using nanosystems as the building blocks. The department studies to some extent theoretically and mostly experimentally the individual elementary excitations as spins, electrons and photons, as well as individual material objects as atoms and molecules, at the nanoscale.

The programme is based on structures realized through advanced nanotechnology in which physical effects can be isolated so that model systems are formed. The structures are made through top-down processes such as lateral quantum dots or superconducting circuits, or through bottom-up fabricated devices containing a molecule, a single atom, a nanowire, a carbon nanotube, or a graphene piece. Largely experimental, the group also includes good theorists.

Quality:

The group performs excellent research, building upon an outstanding tradition, established by leaders with superb academic records, including Hans Mooij, Cees Dekker and others. It is also because of this group that TU Delft is known in the world as the home of quantum nano. The group publishes in the highest impact journals and is extremely well cited (MNCS of 2.80 over the reviewed period, way above the national average of 1.87).

Productivity

The group has produced a very high number of papers. A considerable number of PhD students (53) have successfully finished their PhD project (a success rate of 86%).

Relevance

The group investigates and seeks novel quantum nano effects, sometimes by necessity a bit disparate. This is academically very solid research, generally not immediately applicable, but extremely good for the training of research engineers, and of high societal relevance. The research appears quite promising in view of future applications, since quantum nano is in principle relevant to the future of electronics. The group happily mixes with industry in Kavli Nanolab, through contracts and in other forms. They initiated the SmartMix consortium Nano Imaging under Industrial Conditions (NIMIC), in which they play a key role and collaborate with industrial partners, such as Haldor Topsøe, Albemarle, FEI Company, and with health institutes.

Viability

The research programme is very viable and well balanced. The earning capacity is impressive. The group is a healthy mixture of experienced, quite famous masters, younger and strongly upcoming faculty and researchers and active and ambitious postdocs and students. The Committee met during the site visit a highly motivated faculty, as well as postdocs and PhD students.

Conclusion

This is a very strong group, very viable and extremely active.

Programme TUD 5: **Radiation Physics for Energy and Health**

Programme director: Prof. T.H.J.J. van der Hagen

Research staff 2009: 61.9 fte

Assessments:	Quality:	4
	Productivity:	4
	Relevance:	5
	Viability:	5

The mission of the group is to perform research at advancing understanding in (nuclear) radiation phenomena, thereby engineering and applying these insights in societal-relevant research issues in health and energy. The programme focuses on radiation research in the areas of energy and health.

Energy research includes reactor systems of the fourth generation and beyond, and material studies on tailored materials for energy saving, storage and conversion.

Health research comprises functional materials for imaging (scintillators), imaging detectors and complete imaging systems, the use of radiation and radionuclides for microscopic structural studies, diagnostics and therapy, and innovative production routes of relevant radionuclides.

Quality

In the observations of the Committee the group for Radiation Physics for Energy and Health is itself in an energetic and healthy state. The improvement activities as suggested by the 2003 review committee have been fully implemented and staff has been significantly rejuvenated. This has led to a group with a clear vision and ready for the tasks ahead. Besides being the expertise centre for the Netherlands for nuclear knowledge this group is active in a broad range of nuclear related applications. One highlight is the spin-echo neutron scattering device allowing a significantly reduced equipment footprint with an increased illumination capability improved by three orders of magnitude, allowing dynamic imaging. This equipment has been copied in the ISIS facility and is enjoying significant international attention. Another highlight is the invention that allows an improvement of the production process for the ^{99}Mo isotopes, the workhorse of radiologists worldwide, with a factor of 3000.

The programme leader has nationally very strong visibility and is considered a leader in this field in the Netherlands. The group and the group leader have established a very strong programme with an integrated experimental and theoretical research towards improving the sustainability of nuclear energy in reactor physics. In this, the group can build on strong collaborations with European groups. While the impact of the group judged by the MNCS method 1.35, it is in fact much more substantial.

Productivity

The productivity of this group is very good. It awarded a PhD to 42 candidates, but also produced a significant number of patents, 29. This besides the developed equipment mentioned above. All PhD projects are for 100% funded from funds outside the university, quite an accomplishment and quite rare.

Relevance

The Dutch government expressed the ambition to install two new reactors for the production of energy in the Netherlands in the coming period. This requires a much improved and broader knowledge base in the country than available currently. Besides this a large number of companies

in the Netherlands depend on the knowledge available in this group for the application of nuclear physics.

Viability

No doubt the group is vibrant, capable and aggressively encountering the problems for the future, a group appearing capable, of proper structure and a broad and accepted knowledge base. The group is invited to show their capability with more authority to the outside world.

Conclusion

An impressive and successful group, that should attract many students to physics and capable to be entrusted to carry the load for the Dutch society. The Committee was most impressed by the spin-echo small-angle neutron scattering equipment at RID, which allows analysis of materials with a very efficient use of a neutron beam. This engineering feat has drawn a high level of attention in the nuclear analysis community around the world. At ISIS a derived reflectometer was installed by the group. The group is currently promoting the OYSTER project: Optimized Yield for Science and Education of Radiation, upgrading the core of the reactor by making it more compact and increasing power from 2 to 3 MW to yield an intensity gain up to two orders of magnitude of neutrons and positrons.

Although the Committee is not in a position to specifically comment on the merits of the OYSTER project, the engineering capability of this group appears strong enough to carry this project through.

11A. INSTITUTE LEVEL - Leiden University

University: Leiden University
Faculty: Faculty of Science

1. The institute

Leiden University's Faculty of Science encompasses eight institutes, among which the Leiden Institute of Physics (LION). The mission of LION is to perform physics research and provide physics education at the highest international level. Research at LION covers a broad spectrum of subjects, ranging from cosmology to the mechanics of DNA, from the physics of jamming in granular materials to quantum nanomechanics, from protein folding to superlubricity. Research at LION is organized in four programmes: Condensed Matter (including surface science, nanophysics and soft condensed matter), Quantum Optics, Biological and Molecular Physics, and Theoretical Physics.

The Institute is led by a Scientific Director, who carries integrated management responsibilities, and is accountable to the Dean of the Faculty. He is assisted by the Institute Manager who focuses on financial control and technical support.

The coordination team consists of the Scientific Director, Institute Manager, and Teaching Programme Director, together with the chairpersons of the four research programmes.

Assessment/remarks

The Committee was impressed by the welcome it received from the Dean of the Faculty, the staff and students. Physics at Leiden has been, and continues to be, at the highest levels, which was once again supported by the information the Committee received during the visit.

2. Quality and academic reputation

The academic reputation of the Institute is determined by the reputation of its researchers. Four of the current staff are members of the KNAW, the Royal Dutch Academy of Arts and Sciences, two out of twelve winners of the Spinoza laureates in physics are from Leiden, three out of a total of eight ERC (European Research Council) Advanced grants in physics awarded to Dutch physicists have gone to researchers from Leiden.

International collaboration has been established with the University of California (Santa Barbara), IBM Research Labs and through guest lecturers exchanges, in particular the Lorentz visiting professorships (2004 Leonard Susskind, 2005 Peter Zoller, 2006 David Nelson, 2007 Thomas Kibble, 2008 Duncan Haldane, 2009 Kip Thorne).

Assessment/remarks

Quality levels are uniformly high for all the programmes which were judged to be internationally leading in all cases. This is a remarkable achievement for any university worldwide.

3. Resources

New research staff is selected via broad and open international recruitment, and is appointed on a tenure-track contract as assistant professor. After six years the assistant professor is evaluated by a committee involving international experts. Successful candidates receive tenure and promotion to an associate professor position. Roughly five years later these associate professors are re-evaluated for promotion to a full professorship.

The normalized total staff has increased from 119.5 fte in 2004 to 151.7 fte in 2009. In 2009 almost 50% of the total research staff is PhD student and roughly 25% postdoc. The total funding of the Institute has increased from almost M€ 12 in 2004 to M€ 16 in 2009. The share of direct funding has decreased in favour of the funds received in (inter)national competition. Since 2008 external funding exceeds direct funding, with a ratio 4:3 for 2009.

Assessment/remarks

The Committee received a tour along the research facilities of the Department and was impressed by the research infrastructure in Leiden. Facilities like low temperature labs are unique and very supportive for the development of high quality innovative research. The Department seems to be able to attract high quality staff and adequate research funds.

4. Productivity

It is the policy of the institute to publish research articles in high-profiled refereed journals in order to increase the visibility and impact of the research output. The average number of refereed publications per year is 171, with an average total staff input of 135.5 fte, leading to a publication rate of 1.26 refereed articles per (total staff) fte per year. The results of the CWTS-analysis show that the Leiden programmes under review have produced 1172 articles in Web of Science journals in the years of the review period. These articles were cited 12 993 times, not counting self-citations. The mean citation score is 10.59 for Theoretical Physics, 11.87 for Condensed Matter, 10.00 for Quantum Optics and 11.82 for Biological and Molecular Physics. The number of refereed articles in 2009 per full-time equivalent of academic staff ranges from 1.08 (Quantum Optics) to 2.22 (Theoretical Physics) in the programmes under review. The average output for the Leiden programmes in the period to be reviewed is 1.70. The average output per fte in all the programmes in this Physics review is 1.90.

Assessment/remarks

Productivity was at the highest level almost uniformly and the one programme that was marginally lower was still excellent.

5. Societal Relevance

LION is orientated towards fundamental questions which provide a basis for new ideas leading to applications and innovations. The Condensed Matter programme has been active in forging industrial ties, partly fuelled by the SmartMix programme NIMIC. Industrial LION partners include Philips and IBM; these collaborations have led to joint patent applications and development of instrumentation.

Experimental Physics at LION has a strong tradition in instrumentation development. In the self-evaluation report several spin-off companies of LION are mentioned

Assessment/remarks

With regard to societal relevance the programmes were all at a very high level. This is remarkable in view of the fact that Physics at Leiden focuses on curiosity-driven goals that might have ultimate societal impacts that are difficult to judge in the short term. Nonetheless, the development of students, outreach and ideas are of significant and broad impact, leading to excellent programmatic relevance.

6. Strategy for the future

The Institute aims at successfully addressing funding sources for project grants to achieve a financial healthy position. Furthermore the Institute aims at continuing the strategy of a strong cohesion, state-of-the art instrumentation and facilities and an ambitious and talented staff.

Assessment/remarks

In all areas the viability of programmes was judged to be fully adequate to assure continuing rejuvenation and development. Administrative support appears to be high with the appropriate faculty positions and start-up packages being made available. In the quantum-optics area the long term viability of a key recent appointment which is split with a US university still remains to be determined. The arrangement appears to be working very well and contributing substantially through collaborative synergies between the institutions at the moment. We are hopeful that this will continue into the future in spite of the difficult logistical arrangements that have to be made.

7. PhD Training

The Faculty of Science of Leiden University has created a Graduate School to organize its PhD programmes. The Graduate School oversees admission, registration, and performance of the PhD students, and offers them a programme of courses and trainings. PhD students receive an Education & Supervision Plan, which is updated every year as part of the student's performance review. All PhD students participate either in the nation-wide Dutch Research School for Theoretical Physics, or the Leiden/Delft Casimir Research school. Both schools offer a programme of topical courses and workshops. All PhD students follow these courses, and attend one or more summer school, workshop or conference per year, where they present their work. PhD students write several journal papers (3-10) and guide one or more MSc and/or BSc students.

The dropout rate of PhD students is 8%. The average period between the start of a PhD project and approval of the candidate's thesis has dropped from just above 4.5 years in 2005 to 4.02 years in 2009

Assessment/remarks

The Committee met an enthusiastic and involved group of PhD students, who are all very satisfied with the supervision they get. The success rate of the PhD students is excellent with a very small drop-out rate of 8% and an average progress of 4 years.

9B. PROGRAMME LEVEL - Leiden University

Programme LEI 1: **Theoretical Physics**
Programme director: Prof. C.W.J. Beenakker
Research staff 2009: 39.2 fte

Assessments: Quality: 5
 Productivity: 5
 Relevance: 4
 Viability: 5

The proclaimed mission of the group is to promote insight into the wonder that the same physical laws and mathematical concepts apply to the whole of nature, from the largest to the smallest energies and length scales. The research area of the programme therefore covers three different energy scales: At the low-energy scale the quantum physics of nanoscale and strongly-correlated condensed matter at low temperatures; at the high-energy scale the physics of elementary particles and cosmology; at the intermediate-energy scale the statistical physics at room temperature of soft condensed matter and biological matter. The Committee appreciates the sense of scientific direction of this research group, where priority is given to formulating important physics questions, upon which techniques are subsequently brought to bear – rather than the opposite.

Teaching and outreach are strongly emphasized. The group strongly supports the Lorentz Center, which represents a strong centre of attraction towards Leiden, and a powerful tool to expose students to the best physics worldwide. The group partners with external partners to recruit PhD students into the Leiden-Delft Casimir Research School, with Leiden Astronomy on a cosmology MSc, with Amsterdam and Utrecht on a plan to build a western European institute similar to the Scandinavian NORDITA or to the Canadian Perimeter Institute.

Quality

The research quality at low and intermediate energies is of top international quality, with recent ERC grants and other awards. The research in high energy is very good. At the lowest energy and temperatures there is nanoscience and strongly correlated electron physics, where the group has been very active, notably in the physics of graphene, using the two-valley structure as a pseudospin. The possibility to find solid state Majorana fermions is now a focal point, in active collaboration with the Quantum Nano group at Delft. Another exciting line involving application of string theory to condensed matter is an AdS-CFT attack on strongly correlated models for Hf-Tc superconductivity.

In high-energy physics there is good activity in string theory within a wide network of international collaborations. There is no experimental high-energy physics or theoretical work directly related to it, which decouples the group somewhat from LHC physics, but a new hire in cosmology will provide a welcome fresh perspective.

At intermediate scales, the statistical physics work on the stacking of DNA nucleosomes inside chromatin fibres is quite interesting. Another line is that of granular systems, where the development of criticality at the jamming transition has been investigated. The continuation of this quite successful line is assured, despite a recent move into FOM administration. Another fresh hiring has been made in the field of complexity, specifically econophysics.

Productivity

The group is highly productive, and its work is well recognized. Besides the excellent impact parameters, the Committee finds the choice of themes of high relevance to current physics issues.

Relevance

The high societal relevance of a good theory school, where model-building and problem-solving are used daily for scientific higher education, is undeniable, even if the direct impact on industry is modest. There is nevertheless some involvement in industrial themes in conjunction with the “Solid-State Quantum Information Processing” project - which involves Microsoft and Delft’s Quantum Nano group, with the oil industry (FOM-Shell IPP) on soft matter, and with banks and consulting firms in econophysics. Outreach has been particularly well implemented, including very visible public lectures.

Viability

The Leiden theory group represents a good mix of various levels of seniority, diversity of approaches and lines, curiosity and openness for novelty. High-energy is relatively under-represented, although the new hire in cosmology may mitigate this concern. The new directions that are being explored in the life sciences and econophysics represent natural lines of growth.

Conclusion

The group is mostly excellent, always very good, with strong and ambitious leadership and a clear strategy for collaboration and development. It is certainly worthy of strong and continuing support.

Programme LEI 2: **Condensed matter physics**

Programme director: Prof. M. van Hecke

Research staff 2009: 39.3 fte

Assessments:	Quality:	5
	Productivity:	5
	Relevance:	5
	Viability:	5

The stated mission of the group is to probe fundamental electronic, mechanical and chemical properties of condensed matter on scales ranging from the millimetre to the atom in a compact, intellectually stimulating and collegial setting. The research area comprises three main activities. The Interface Physics group uses various types of Scanning Probe Microscopy to investigate the structure and dynamic behaviours of surfaces and interfaces. The Nano-Physics/Hard Matter group works in the fields of electronic transport of molecular and atomic sized conductors, and in spintronics and superconductivity. The Soft Condensed Matter group focuses on the flow and mechanics of disordered materials.

In the past decade the focus has shifted from ‘traditional’ condensed matter problems involving bulk materials with an emphasis on magnetism, to surface/interface physics, nanoscale physics and soft condensed matter. Starting with well posed physical questions, the approach is to develop existing or in most cases new techniques to bear onto them.

Teaching and outreach are strongly emphasized. The group participates in the Lorentz Center activities, and partners with outside forces to recruit PhD students in the Leiden-Delft Casimir Research School.

The group wins many important contracts, at the national and European level. Relations with industry are especially active, particularly for the interfaces and soft matter groups.

Quality

The research quality is of top international quality, with impressive output on all lines. In nanophysics, the questions deal with quantum conductance and spintronics at atomic and molecular nanocontacts, a theme for which the group pioneered the technique of mechanical break junctions. With this method, promising research is going on in many directions, most recently in intra-molecular interference. In interfaces, research is strong in both fundamental and applied directions, dealing on one hand with nanofriction, and on the other on the atomistic study of catalysed chemical reactions with novel surface science techniques capable of working in realistic, high pressure conditions, with an original LEEM/PEEM facility freshly built. In soft matter, granular rheological research reveals new phenomena such as sand liquefaction. On jamming, there is strong in-house collaboration with the Theoretical Physics group. Other inspiring projects are going on lines including single nuclear spin detection, microscopic understanding of Fischer-Tropsch catalytic reactions, control of sliding friction, and mechanical metamaterials.

Productivity

The productivity is high, with all statistical indices well above average. Praiseworthy is the double accent of the research efforts and papers to simultaneously and clearly address curiosity driven fundamental physics themes alongside with relevant, practical problems and demands from industry and society.

Relevance

The approach of this group exemplifies how condensed matter physics provides a natural laboratory for model building and problem solving which is of high societal relevance for scientific higher education.

The group accompanies this with a large direct impact and collaboration with industry, with involvement both in connection with catalytic reaction studies and with rheological studies. With Delft, the group participates in NIMIC (Nano IMaging under Industrial Conditions), a programme where many industries also converge. IBM has been involved through the building of the LEEM/PEEM facility by IBM's R. Tromp, who is also part-time professor at Leiden. A spinoff company, LPM, has been generated by the interface physics group. Collaboration with, and involvement of, the oil giant Shell is ongoing both in soft matter on "Innovative Physics for Oil and Gas", and in interfaces on the study of the Fischer-Tropsch process, a set of catalytic chemical reactions that convert a mixture of carbon monoxide and hydrogen into liquid hydrocarbons.

Viability

The Leiden Condensed Matter group represents a good mixing of various levels of seniority, diversity of approaches and lines, curiosity and openness for novelty.

Conclusion

The group is excellent, and should continue that way.

Programme LEI 3: **Quantum optics**
Programme director: Prof. D. Bouwmeester and Dr. E.R. Eliel
Research staff 2009: 19.4 fte

Assessments: Quality: 5
 Productivity: 5
 Relevance: 4
 Viability: 4

The mission of the group is to explore the limits of our understanding of the quantum mechanical properties of light and its interaction with matter. Quantum entanglement of photons has been the dominant theme during the first half of the five-year evaluation period, accompanied by a parallel effort in plasmonics. The joining of two researchers gave rise to several new research lines at the interface of quantum optics, solid state physics and biology. This implies a significant shift in the research focus and vision for the group, placing much more emphasis on interdisciplinary research and nano-scale science.

Quality:

The research of the Quantum Optics group in Leiden has always been at the very highest and internationally leading level, both concerning experimental investigations and theoretical studies. For example, the classical optics part of the research programme is famous for the discovery of novel effects like the orbital angular momentum of light beams or the violation of Snell's law of light reflection for a laser beam. The quantum optics part is equally famous, for example for the groundbreaking demonstration that entangled photons can be converted to entangled plasmons travelling through apertures behind which the plasmons are reconverted to entangled photons, and this in the presence of dissipation. The recent addition of a mechanical optics part, concentrating on the quantum mechanical coupling between photons and phonons of microscopic objects, is highly promising and has already produced ground breaking results. Many other intriguing effects have been demonstrated, too many to list them here in detail. Most of these effects have been first-ever observations and have received the widest recognition in the international community, for example via invited talks on premier international conferences.

The new ideas developed in the group on knotted light beams and spatial quantum superpositions of optical mirrors, objects of everyday life, might lead to further developments and deeper understandings in such diverse fields as plasma physics and general relativity, respectively. The research results are innovative and sometimes breathtaking, both in experimental and theoretical physics. Many of the results address the small audience of physicists working in classical optics, a research field which is sometimes considered outdated. But the group has repeatedly demonstrated this prejudice to be clearly wrong.

Productivity:

Over many years and even decades, the findings of the Quantum Optics group have resulted in a constant stream of publications at the highest international level. The group is often invited to give talks, participates in editorial boards and performs outreach activities.

Relevance:

The results of the Quantum Optics group are highly relevant for their immediate community of physicists working in such diverse fields as classical optics, quantum optics, plasmon optics, and optomechanics. However, their results are not limited to these communities. Instead, the ideas produced by the group stretch out into plasma physics and general relativity, to name just two

examples. The discovery of knotted light beams where closed electric field lines are interwoven might be relevant for the design and operation of future fusion machines, in particular tokamaks. The possibility to generate by means of a single photon a spatial superposition of a macroscopic object like a mirror addresses fundamental issues of general relativity. The group even explores the possibility to tailor light fields in such a way that two-dimensional systems like graphene can be simulated.

Viability:

The research themes of the Quantum Optics group are topical, attractive and increasingly interdisciplinary. The transfer of experiments into a new laboratory with improved vibration isolation in the not-too-distant future will boost the group's capabilities and enable new experiments in the quantum domain of opto-mechanics.

The recent retirement of two senior professors has been successfully mastered by hiring a new professor of the highest calibre. The new professor is deliberately delocalized over two remote universities, mainly because the two universities offer orthogonal research opportunities. This provides a clear strength for the Quantum Optics programme as it allows the group as a whole to benefit from the better of both worlds, low-temperature physics in Leiden and nanophysics in the other place. However, it can also be considered a weakness as it makes the group vulnerable to external and thus uncontrollable perturbations. At some point in the future the travelling might also impose burdens on the programme leader.

Conclusion:

The review committee highly recommends further strengthening the Quantum Optics group in the development of their innovative research. The group's effort to grow in order to put the programme on a broader basis should be strongly supported.

Programme LEI 4: **Biological and molecular physics**

Programme director: Prof. T.J. Aartsma

Research staff 2009: 27.3 fte

Assessments:	Quality:	5
	Productivity:	4
	Relevance:	4
	Viability:	5

The mission of the group is research in (bio) molecular physics and advanced spectroscopy with a focus on the photophysics of single molecules and nanoparticles. Single-molecule approaches have made it possible to detect, identify, track, and manipulate single (bio) molecules and nanoparticles in an ambient environment and even within a living cell. This has inspired a parallel and growing research theme on the physics of life, involving the study of structural and dynamical aspects of biomolecular functions ranging from the molecular scale to that of the cell. The aim is to elucidate cellular and sub-cellular molecular mechanisms in an integrated approach involving close cooperation with biochemists and biologists.

Quality

This is a very dynamic group with highly ambitious and well thought out projects for research on the “physics of the cell.” Their motivation stems from fundamental questions in the mechanics of cell function – chromatin packaging in the nucleus, mechano-sensors and mechano-transduction, and protein miss-folding and aggregation (e.g. amyloid formation) – and the group develops new and unique probes and techniques for investigating these cellular functions. Their embedding in the “Cell Observatory” affords close cooperation with chemists, biologists and even computational scientists on problems of cell function, growth and differentiation.

An important strength of the programme is the ability to do measurements in living cells and in real time. The techniques developed and employed by this group will provide a platform upon which many other studies can be conducted. It is felt that the fundamental nature of the questions asked and the detail with which they can be answered will lead to lasting contributions to our understanding of the physico-chemical workings of the cell.

The published papers are of the first order and have appeared in the top journals. They are setting the standard for what can (and should) be measured in biological systems, leading to a fundamental, quantitative, mechanical understanding of cellular function.

Productivity

The output is very good and increasing. The group has redirected and positioned itself to exploit its expertise in spectroscopy as applied to biological systems. The group is in particular very active in giving talks and presenting posters. It has also successfully supervised a number of PhD students.

Relevance

There are potential applications to important societal needs (e.g. amyloid formation related to Alzheimer’s), but these are still in the potential stage; hence the 4.0 rating.

Viability

The group has redirected its effort and expertise to the physics of the cell, which is both important for science and society and attractive to students.

Conclusion

This is an emerging top programme in the physics of the cell. The group has unique skills and expertise that will enable them to answer fundamental physics questions about cellular function. The problems they have chosen and the techniques they deploy are well matched. It is expected that the basic results obtained through their studies will be of lasting value to the scientific community and will show the way for how physics can contribute in a substantial and fundamental way to biology.

Appendix 1: Explanation of the SEP criteria and scores

The four main criteria for assessment are: Quality, Productivity, Relevance, and Vitality & feasibility. The assessment at the institute level primarily focuses on strategy and organisation, whereas the assessment at the level of the research group or programme primarily focuses on performance and activities of researchers and the results of their work (output and outcome).

Quality	The level or degree of excellence of the research, compared to accepted (international) standards in that field. The scope of the term ‘research’ is not limited to the research results. Research management, research policy, research facilities, PhD training and the societal relevance of research are considered integral parts of the quality of work in an institute and its programmes.
Productivity	The relationship between input and output, judged in relation to the mission and resources of the institute.
Relevance	Social, economic and cultural relevance. Aspects to be considered are: <ul style="list-style-type: none"> ▪ <i>Social quality</i>: efforts of the institute or group to interact in a productive way with stakeholders in society ▪ <i>Social impact</i>: how research affects specific stakeholders or procedures in society ▪ <i>Valorisation</i>: activities aimed at making research results available and suitable for application in product, processes and services. Committee members can also remark on relevance for the academic community, but the assessment should be on societal relevance.
Vitality & feasibility	The ability to react adequately to important changes in the environment. Also vision for the future.

The scores on a five-point scale are:

5 Excellent	Research is world leading. Researchers are working at the forefront of their field internationally and their research has an important and substantial impact in the field.
4 Very Good	Research is considered nationally leading. Research is internationally competitive and makes a significant contribution to the field.
3 Good	Research is considered internationally visible. Work is competitive at the national level and makes a valuable contribution in the international field.
2 Satisfactory	Research is nationally visible. Work adds to our understanding and is solid, but not exciting.
1 Unsatisfactory	Work is neither solid nor exciting, flawed in the scientific and/or technical approach, repetitions of other work, etc.

Appendix 2: Short profile of the members of the Committee

1. Subcommittee Groningen, Twente, Nijmegen (RUG, UT, RU)

Hilbert von Löhneysen, Physikalisches Institut, Universität Karlsruhe (TH). Physics of metallic layered systems and nanostructures, properties of strongly correlated electron systems (heavy-fermion systems, rare earth and transition-metal compounds), magnetism and superconductivity, metal-insulator-transitions.

Masao Doi, Department of Applied Physics, Graduate School of Engineering, The University of Tokyo. Research interests: Soft matter physics, rheology of polymers near the interface (adhesion, contact line motion), Modeling and simulation of polymeric materials.

Monika Ritsch-Marte, Full Professor for Medical Physics at the Medical Faculty of the University of Innsbruck (now Medical University of Innsbruck). Quantum Optics, especially laser fluctuations, squeezing, nonlinear optics, atom interferometry. Since 1998: Biomedical Applications of Lasers, especially optical micro-manipulation, (spiral) phase contrast microscopy, nonlinear microscopy (CARS microscopy), optoacoustics.

Albrecht Wagner, particle physicist, former Chairman of the Directorate of DESY in Hamburg. He was previously Professor of Experimental Physics and Research Director at Hamburg University. He has conducted scientific research at the University of Heidelberg and at the Lawrence Berkeley Laboratory (USA). From 1974 to 1986, he worked on experiments at DESY's DORIS and PETRA storage rings, and from 1982 to 1991 at the research center CERN in Geneva. In 1991, he took up a post as a professor of experimental physics at the University of Hamburg and became research director of DESY.

Friso van der Veen, Full Professor of Experimental Physics at the ETH Zurich since May 2000. Head of the Research Department of Synchrotron Radiation and Nanotechnology at the Paul Scherrer Institut in Villigen. 1990 - 1996: Technical director of the FOM-Institute for Atomic and Molecular Physics, Amsterdam.

1987 – 1992: Professor of surface physics, Leiden University.

1992 – 1997: Professor of technical physics, University of Amsterdam.

1997 - 2000: Professor of experimental physics, University of Amsterdam; director of Van der Waals-Zeeman Institute.

2. Subcommittee Eindhoven, Amsterdam (TUE, UvA, VU)

Friedrich Wagner, 1993-2008 Director Max-Planck-Institute of Plasma Physics. Retired 2008. Research interests: High-temperature physics and fusion research. Since 1999 Friedrich Wagner has been Professor of Physics at Ernst Moritz Arndt University in Greifswald, and since 2007 President of the European Physical Society.

Siegfried Bethke, Professor of Physics, Director Max Planck Institut für Physik. Research interests: Experimental Particle Physics at high-energy colliders, Development of particle detectors, Experimental tests of quantum chromodynamics, Experimental astro-particle physics.

Paul Chaikin, New York University. Soft condensed matter physics. Research interests: Effects of dimensionality, Coulomb correlation, disorder in condensed matter systems, spindensity-wave

states and superconductivity in organic metals, superconducting wire networks, colloidal physics, sedimentation in fluidized beds.

Phil Bucksbaum, professor of applied physics, director of the Ultrafast Science Center, SLAC, Stanford University. Main research interests:

- fundamental light-matter interactions, and especially the control of quantum systems using ultrafast laser fields.
- developing new sources of ultrafast laser light in the infrared, visible, ultraviolet, and x-ray regions of the light spectrum.

Jean-Louis Martin, director of the Laboratoire d'optique et biosciences, École polytechnique (CNRS, INSERM). Président of the scientific council of INSERM. Director of the SupOptique (Institut d'optique théorique et appliquée).

Martin Stutzmann, TU München, Walter Schottky Institute, Centre for Nanotechnology and Nanomaterials. Research interests: Defects and electronic transport in semiconductors, optical and spin resonance spectroscopy, hydrogen in semiconductors, Laser crystallization and processing of semiconductors, large area electronics and photovoltaics, silicon based sheet polymers, electronic properties of semiconductors with wide bandgap (III-nitrides, diamond, suboxides), CVD and MBE growth, high electron mobility transistors, semiconductor sensor devices and biosensors, biofunctionalization of semiconductor surfaces.

3. Subcommittee Utrecht, Delft, Leiden (UU, TUD, LEI)

Sanjoy Banerjee, professor of chemical engineering and director of the Energy Institute, City University of New York (CUNY). Research interests: the behaviour of systems far from equilibrium, including rapid phase transitions, turbulence and nonlinear phenomena such as dendrite formation in electrochemical energy storage systems.

John Brady, Chevron Professor of Chemical Engineering, California Institute of Technology. Fluid mechanics and transport processes; Complex and multiphase fluids.

Jonathan Richard Ellis, Clerk Maxwell Professor of Theoretical Physics at King's College London. After post-doc positions at SLAC and Caltech, he went to CERN and has held an indefinite contract there since 1978. His activities at CERN are wide-ranging. He was twice Deputy Division Leader for the theory division, and served as Division Leader for 1988–1994. He was a founding member of the LEPC and of the LHCC.

Rob Hartman, Director Strategic Technology Programme ASML. Member of the Committee Action Plan Physics 2007 and member of the mid-term review committee for Physics research at the technical universities in 2008. ASML is a world leader in the manufacture of advanced technology systems for the semiconductor industry. The company offers an integrated portfolio for manufacturing complex integrated circuits.

Jürgen Kurths, Head of research domain Transdisciplinary Concepts & Methods at the Potsdam Institute for Climate Impact Research (PIK), where he examines the dynamics of complex networks and brings a new approach to the understanding of climate change and its interaction with ecology and socio-economy. He is also professor of Nonlinear Dynamics at the Institute of Physics at the Humboldt University of Berlin.

Gerhard Rempe, Director and Scientific Member at the Max-Planck-Institut of Quantum Optics and Professor at the Technical University of Munich (since 1999). Research interests: Bose-Einstein condensation, Cavity QED in an optical resonator, Cold Polar Molecules, Quantum Information Processing.

Erio Tosatti, International School For Advanced Studies (SISSA),Trieste. Research interests: Nanofriction: Theory and Simulation, Theory of Metallic Nanocontacts, Especially Magnetic, Mott Insulating and Unconventional Superconducting States of Fullerides, Strong Electron Correlations at Surfaces, Physics of Ultra-High Pressures, Quantum Effects near Ferroelectric and Structural Phase Transitions.

