

**RESEARCH REVIEW**

**APPLIED PHYSICS**

FACULTY OF SCIENCE AND TECHNOLOGY

**UNIVERSITY OF TWENTE**

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# REPORT ON THE RESEARCH REVIEW OF APPLIED PHYSICS OF THE UNIVERSITY OF TWENTE

## 1. FOREWORD BY COMMITTEE CHAIR

This report results essentially from two complementary efforts, as prescribed by the Standard Evaluation Protocol 2015-2021 for research reviews in the Netherlands. On the one hand the discipline of Applied Physics at the University of Twente looked critically back on the years 2010 – 2016 and drew its conclusions for the forthcoming years. The resulting self-evaluation report, on the other hand, was subjected to an independent outside scrutiny by the international review committee, which culminated in two days of intense dialogue at a site visit in Enschede. The present document summarizes the findings by the review committee. We hope that it is a transparent and fair assessment of the quality and relevance of the research being done in Applied Physics at the University of Twente.

Apart from the indisputable accountability of the academic world towards society, there are immediate benefits of this enormous effort, which are worth mentioning. The University of Twente and the Faculty of Science and Technology obviously adopted the effort as a chance to position themselves internationally, and to anticipate and forestall possible threats. Hence, the assessment fell into a time of major structural change, which will be commented in this document. The committee enjoyed the chance to reflect the spirit of excellence, the dialogue about research strategy and targets, and to share their thoughts about international trends in science and society.

Many persons were involved to make the effort as enjoyable as it turned out to be. On behalf of the review committee I would like to thank them all, in particular Prof. dr. R. M. van der Meer (discipline chair, Applied Physics) and Prof. dr. H. Hilgenkamp (Dean of the Faculty of Science and Technology). Last, but not least, QANU provided invaluable professional assistance in person of MSc Peter Hildering.

Prof. D.E. (Dietrich) Wolf, Chair of the Committee  
Professor Theoretical Physics, Universität Duisburg-Essen

May 2018

## 2. THE REVIEW COMMITTEE AND THE PROCEDURES

### **2.1. Scope of the review**

The review committee Applied Physics was asked to perform a review of research conducted between 2010 and 2016 in the Applied Physics unit at the Faculty of Science and Technology of the University of Twente.

In accordance with the Standard Evaluation Protocol 2015-2021 (SEP, amended version September 2016) for research reviews in the Netherlands, the committee's tasks were to assess the quality, the relevance to society and the viability of the scientific research at the research unit as well as the strategic targets and the extent to which the unit is equipped to achieve these targets. A qualitative review of the PhD training programme, research integrity policy and diversity also formed part of the committee's assignment.

The Executive Board of the University of Twente provided the committee with Terms of Reference concerning the assessment. In this document, the Board asked the committee to pay special attention to and offer recommendations in the assessment regarding the following questions:

1. Does the new governance of faculties and research institutes allow Applied Physics to sufficiently engage in emerging topics?
2. Are the clusters in applied physics adequately capable of executing their role; in particular do they foster peer consultation and support within the cluster and, secondly, talent management, specifically the attraction of young staff?
3. Are young scientific staff members, specifically tenure trackers, in Applied Physics sufficiently supported and empowered to pursue their scientific career ambitions?

### **2.2. Composition of the committee**

The composition of the committee was as follows:

- Prof. D.E. (Dietrich) Wolf, Professor Theoretical Physics at Universität Duisburg-Essen;
- Prof. T. (Teresa) Puig, Head of the Superconducting Materials and Large-scale nanostructures at the Institute of Materials Science of Barcelona (CSIC);
- Prof. E. (Elisabeth) Guazzelli, Senior Researcher of the Centre National de la Recherche Scientifique (CNRS) at Aix-Marseille Université;
- Prof. S. (Stefan) Blügel, Head of the Peter Grünberg Institute and the Institute for Advanced Simulation at the Forschungszentrum Jülich;
- Prof. P. (Peter) Uhd Jepsen, Professor of Ultrafast Infrared and Terahertz Science at the Technical University of Denmark.

The committee was supported by Peter Hildering MSc, who acted as secretary on behalf of QANU.

### **2.3. Independence**

All members of the committee signed a statement of independence to safeguard that they would assess the quality of the Applied Physics unit of the University of Twente in an unbiased and independent way. Any existing personal or professional relationships between committee members and the research unit(s) under review were reported and discussed in the first 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.

### **2.4. Data provided to the committee**

The committee received the self-evaluation report from the unit under review, including all the information required by the SEP.

The committee also received the following documents:

- the Terms of Reference;
- the SEP 2015-2021, amended version September 2016;
- appendices to the self-evaluation report:

- scientific staff of the unit Applied Physics;
- number of scientific research staff in fte per Research Group;
- output per Research Group;
- key publications per Research Unit;
- Academic appreciation and relevance to society;
- Performance PhD-candidates per Research Group;
- Research Group Information: mission, research area, highlights and key publications for each of the unit's 13 research groups.

During the site visit, further data was provided by the Applied Physics unit:

- an overview of the research clusters and associated research groups within the Faculty of Science and Technology.

### **2.5. Procedures followed by the committee**

The committee proceeded according to the SEP. Prior to the first meeting, all committee members independently formulated their preliminary findings of the unit under review, and additional questions for clarification based on the written information that was provided prior to the site visit.

The final report is based not only on the documentation provided by the research unit, but also includes the information gathered during the interviews with management and representatives of the research unit. The interviews took place on 26 and 27 March 2018 at the University of Twente. Preceding the interviews, the committee was briefed by QANU about research reviews according to the SEP. It also discussed the preliminary findings and questions, decided upon a number of comments and questions, and agreed upon procedural matters and aspects of the review. After the interviews the committee discussed its findings and comments, allowing the chair to present the preliminary findings and the secretary to draft a first version of the review report.

The draft report was presented to the research unit concerned for factual corrections and comments. In close consultation with the chair and other committee members, the comments were reviewed by the secretary and incorporated in the final report. The final report was presented to the Executive Board of the University and to the management of the research unit.

### **2.6. Application of the SEP and scores**

The committee used the criteria and categories of the Standard Evaluation Protocol 2015-2021 (SEP). For more information see Appendix 1.

## 3. QUANTITATIVE AND QUALITATIVE ASSESSMENT OF THE APPLIED PHYSICS UNIT

### 3.1. Strategy and targets

#### *Organisational context and governance*

The Applied Physics unit is one of the three research disciplines within the Faculty of Science and Technology of the University of Twente. The unit consists of 13 research groups related to three broad areas: Fluid Physics, Materials Physics and Optics and Biophysics. Each group may consist of several chairs occupied by full, associate or assistant professors, and their PhDs and postdoctoral researchers. The groups are headed by group leaders, who are responsible for the research strategy and financial management of the group. The unit Applied Physics is headed by a discipline chair, who represents the discipline as a *primus inter pares* in various committees and boards.

#### *Mission and strategy*

The mission of the Applied Physics unit is:

*'to educate bachelor, master and graduate students in the best possible way in the domain of Applied Physics and to conduct research in selected areas of Applied Physics on an internationally competitive academic level, inspired by relevance to society'.*

The unit has formulated a strategy and ambitions related to this mission, which can be summarized by the following four points:

1. Applying for highly visible research grants on a national and European level in order to consolidate and strengthen the ability to conduct internationally competitive research;
2. Attracting young academic talent using the tenure track system;
3. Seeking multidisciplinary collaboration on intra- and interuniversity levels;
4. Intensifying collaboration with industry.

The committee thinks that this mission is relevant and fitting for the unit, and considers the strategy to achieve the mission appropriate. By specializing in a select number of subdisciplines and by focusing on talent development, the unit maximizes its resources to be internationally competitive. The committee praises the vision and strategic awareness expressed by both the faculty management and the group leaders in the interviews during the site visit. They are aware of the strengths and weaknesses of the unit, and are actively working on improvements, examples of which will be discussed below.

#### *From research groups to clusters*

As of 2017, the research groups started to cooperate in research clusters. Groups with related research topics join forces and cooperate on education, research and external relations. The composition of the clusters emerged from a bottom-up process, in which the groups were asked to find other groups with which they shared a common interest. Groups can participate in more than one cluster. Leadership of the clusters is defined from within, and can take the form of one head of a cluster or a collaborative board consisting of all principal investigators. Examples of clusters and the participating Applied Physics groups are Applied Nanophotonics (CCP, BMPI, COPS, LPNO, OS and XUV), Soft Matter (NBP, NI and PCF) and Nanoelectronic Materials & Thin Films (CCP, CMS, ICE, PIN and XUV). The research clusters are not limited to the Applied Physics unit; some clusters involve groups from the other disciplines within the Faculty of Science and Technology, and in some cases even from other faculties. For instance, the Applied Nanophotonics cluster also hosts two groups from the Faculty of Electrical Engineering, Mathematics and Computer Science

At the moment, the research clusters take the form of informal cooperation. As the cluster structure was implemented only recently, the research clusters are currently exploring the potential benefits of cooperating, such as sharing staff and facilities. Additionally, the faculty management is considering to include the research clusters in the financial allocation model, in which capacity



funding will be tied to certain fields through the research cluster. In this model, new tenure track openings will be allocated to clusters rather than to research groups, with the research clusters discussing the research area in which they want to invest.

The committee is very positive on the future role of the research clusters. It considers the research clusters a good strategy to prevent too much diversification in research topics, and to counter possible imbalances between groups due to their different sizes. By cooperating in clusters, smaller research groups can benefit from each other's expertise, and join forces, for instance when applying for research grants or seeking cooperation with external stakeholders. The committee is also positive about the increased flexibility in the outlines of the new financial allocation model, allowing to take up emerging fields in the cluster structure. It encourages research groups to think about new tenure track positions in terms of emerging topics and challenges, rather than a new opening in an existing area. The multidisciplinary composition of the clusters, which pairs Applied Physics groups with groups in biotechnology, chemical engineering and several other disciplines, further adds to this. Appointing a tenure track researcher in a cluster rather than a research group is also to the benefit of newly hired researchers. It provides them with the opportunity to develop his or her own field within the faculty while benefiting from the expertise of a broad, multidisciplinary group of fellow scientists. The committee recommends the unit to continue on this road, and further develop the research clusters to strengthen the unit's strategic strength.

#### *Institutes and large-scale facilities*

The University of Twente has organized its main research priorities apart from the faculties in three large research institutes on the areas of nanotechnology, health and digital society. These institutes outline the research strategy in these areas, connect researchers in multidisciplinary projects and manage the associated research infrastructure. Researchers from all faculties participate in these institutes and contribute to its funding. The Applied Physics unit is mostly strongly associated with the nanotechnology institute (MESA+), but is also involved in the other two areas.

Before 2018, the research institutes rather than the faculties were responsible for the allocation of financial resources (basic funding) to the research groups, which they did in consultation with the faculties. As of 2018, this has been reversed. The institutes receive a budget for their main mission to initiate multidisciplinary cooperation, but the major part of basic funding is divided by the faculties between their research groups. The strategy behind this change is to allow faculties to better manage their responsibilities in research, education, staffing and housing, and to draw the administrative burden away from the institutes.

The committee agrees with the decision to shift the responsibility for budget allocation to the faculties. The faculties are a more evident place for such decisions as they are responsible for staffing. The institutes might be too large to function as operational entities and are more suited to deal with large-scale cooperation. The committee considers the incentives for multidisciplinary cooperation on emerging topics strong enough without the tool of budget allocation. Research groups are increasingly stimulated to cooperate along the line of the research clusters. The institutes can function as an umbrella for these research clusters, and can provide the infrastructure and support for realizing the university's research priorities. The committee does see a role for the institutes to host for very large research investments and grants, giving the research groups and clusters access to calls for large funds for which they would otherwise be too small. Some of these installations, like MESA+, are very unique and a real opportunity for the researchers in the Applied Physics discipline, so the committee thinks that they should be promoted and their sustainability ensured.

#### *Talent management*

The University of Twente aims to attract, develop and hold on to top talent in order to keep up its high quality of research. To this end, the university has introduced a tenure track system for young staff. Talented researchers are appointed in a personal development track and given room to develop their own independent research line. If completed successfully, the tenure track results in tenured position as assistant professor, and ultimately leads to an appointment of full professor. The progress



of a tenure track researcher is monitored by a tenure track evaluation committee, which decides on each promotion. Most permanent positions within the unit of Applied Physics are currently filled through this procedure. In principle, there is an intended full professor position for each appointed tenure tracker; candidates do not compete with each other.

The committee praises the tenure track system in use by the unit and considers it a very good practice for talent management. The unit has been successful in attracting very talented candidates, which receive excellent support in order to reach their full potential. In the interviews, the tenure trackers indicated that they were very satisfied with their position and the associated freedom to develop as researcher. They felt that the demands set by the university in terms of productivity and the ability to attract external funding were reasonable. With a reduced teaching load, the (in some cases) addition of a PhD position and an relatively independent role they get ample opportunity to develop their research fields. The committee does see a potential risk in the solitary position of tenure track researchers, as they would need a larger infrastructure to be able to apply for the full range of funding opportunities. In this respect, the committee was pleased to hear that tenure track researchers in the future will be more strongly associated with the research clusters, benefiting from the expertise and support of multiple research groups.

### **3.2. Research quality**

To assess the research quality of the Applied Physics unit, the committee considered the performance indicators formulated by the unit in the self-assessment report. These include the research output listed in Appendix 3, as well as marks of recognition from peers such as research grants, awards and membership of prestigious organizations. The findings of the committee are qualitatively discussed for the unit's three research programmes separately, and is quantitatively assessed for the unit as a whole.

#### *Fluid Physics*

According to the committee, the unit conducts world-leading research in the field of physics of fluids. The associated groups are internationally very well-known for their research on fluid physics from the nanoscale to the microscopic scale, including droplets, granular materials, turbulence, wetting and surface flows. The labs are well-equipped and feature some unique instruments. Its researchers have attracted numerous prestigious grants, including NWO Zwaartekracht (Lohse 2014), two ERC Advanced Grants (Lohse 2010, 2016), two ERC Consolidator Grant (Snoeijer 2013 and Lemay 2011), a Vici grant (Mugele 2011), three Vidi grants (Snoeijer 2010, Van der Meer 2012 and Stevens 2016) and many more. The unit also takes pride in the foundation of Max Planck – UT Center for Complex Fluid Dynamics, a research network in which the Fluid Physics group is cooperating with two (German) Max Planck institutes. Leading researcher Detlef Lohse is recognized with numerous honours and awards including a membership of the Netherlands Royal Academy of Sciences and the American Physical Society, a royal decoration and AkzoNobel Science Awards. The group published papers in influential international journals such as Nature and Physical Review Letters, as well as many specialized journal articles, which are highly cited. The committee was very positive about the research output, the research facilities and recognition in this field.

#### *Materials Physics*

The committee was very impressed by the work done in the Materials Physics subdiscipline. The groups are world-leading in the field of Materials Science such as extreme ultraviolet optics, superconductivity, interfaces and surfaces and cryogenics. There exists a good complementarity between basic and applied research. They carry out research in cooperation with major partners such as ITER, CERN and ASML Research, which the committee encourages to continue doing. The labs, including the MESA+ facilities for nanotechnology, are state-of-the-art and very well equipped. Major recognitions in the past years include an ERC Consolidator grant (Brinkman 2013) and Young Academy Memberships (Brinkman, Hilgenkamp), board members of international societies and international conference organizing committees (Hans Hilgenkamp, Marcel Ter Brake, Herman Ten Kate, Alexander Brinkman). During the review period, the group has published influential articles in leading journals such as Physical Review Letters, Nature, and Science as well as many specialized

journals. In recent years, the subdiscipline has started to work on low power electronics driving their initiatives toward neuromorphic concepts. The unit is expanding its work on this direction and has already grouped with other leading institutions. Based on the early results, the committee considers this a very promising research area for which the unit is very well equipped and has the expertise needed to take a world leading role. As will be discussed under Viability, the committee encourages the researchers to continue onto the strategies highlighted in the scientific report. Overall, the committee judges very positively on the work of the Materials Physics subdiscipline.

#### *Optics and Biophysics*

Within the subdiscipline of Optics and Biophysics, the committee sees leading researchers working on a diverse spectrum of subfields in which they are internationally competitive. The subdiscipline uses well-equipped labs and makes use of the impressive MESA+ facilities. Within the subdiscipline, the optics and biophysics researchers often cooperate in joint papers, showing the added value of combining these two subfields in a single pillar. The research quality of the subdiscipline is evidenced by an impressive number of prestigious research grants, including two ERC Advanced Grants (Herek, Barnes), an ERC Consolidator Grant (Garcia Blanco), three Vici grants (Herek, Mosk, Pinkse) and a Vidi grant (Claessens). Researchers have received honours and awards such as a membership of the Netherlands Royal Academy of Sciences (Lagendijk) and memberships of the American Physical Society (Vos, Lagendijk). Also, the group has published leading articles in both specialized journals and prestigious journals such as Nature, Physical Review Letters and Advanced Materials. Overall, the committee has a very positive view of the work in the Optics and Biophysics subdiscipline.

The committee noticed that the three subdisciplines have fluid boundaries: there are many cooperations between the subdisciplines, such as on the topic of surface science, low power electronics and nanotechnology. In the near future, a fourth subdiscipline will be fleshed out on health-related research, to which several groups in the unit will contribute. According to the committee, this cross-cooperation is a sign of a healthy department in which researchers benefit from and add to each other's expertise.

Adding up the work of the three subdisciplines, the committee sees a unit with world-class research quality, with influential output that is impressively well-recognized by the academic community through many prestigious research grants, awards and honours.

### **3.3. Relevance to society**

The unit views the academic education of highly skilled, academically trained engineers and researchers as its main contribution to society. Two thirds of the master graduates in Applied Physics continue their career in industry. As the demand for qualified engineers in industry and society is currently higher than the number of graduates in science and technology, the unit is dedicated to get young people in primary and secondary schools interested in research. To this end, the university participates in many outreach activities, and stimulates and supports its researchers to share their enthusiasm for research with society. Examples include participation in news shows and tv shows on science (National Science Quiz, De Wereld Draait Door, De Kennis van Nu, Galileo), participation in the Twente Science Week, lab tours and activities for kids and teens, guest lectures at schools and participation in (science) festivals.

The unit works very closely together with industry on a number of topics. Printing company Océ is a long-term partner on droplet research and high-tech company ASML on extreme ultraviolet optics, with both partners investing in the associated research groups through research contracts. The unit also has close connections to industry and societal partners on topics such as imaging and biomedical science. Industrial research partners include major companies such as AkzoNobel, BASF, BP, DSM, IBM, Intel, Philips, Shell, Tata Steel and Unilever, as well as many smaller companies. As shown in Appendix 3, contract research amounts to an average of around 5 M€ per year for the unit in recent years, which is approximately 20% of the unit's research budget. The unit also hosts two part-time full professor positions with CERN and ASML, which are paid from societal/industrial funds.



Finally, the university has an active policy in the founding of start-up and spin-off companies and the issuing of patents. The university offers facilities and support for these activities. The possibility of founding a company is brought to the attention of both students and researchers at multiple occasions. The business development team of the university (Novel-T) offers courses on entrepreneurship for master's students and PhD candidates, assists in writing business plans and acquiring seed funding, and can also provide financial support. The university has a fertile environment for start-up companies on the Kennispark Twente close to the campus, especially for the micro- and nanoindustry, which have the opportunity to use the universities' nanolab spaces. Noteworthy spin-off companies from within the unit in recent years include eMALDI BV (electrowetting, 2012), BuBClean (ultrasonic cavitation, 2013), Quantis (silicon nanoparticles for displays, 2014) and SuperACT (superconductivity and cryogenic technology, 2015). Additionally, the unit submits 5-10 patents per year. The university supports patents for 5 years, with the aim to sell it to an industrial partner in this period.

The committee was very impressed by the industrial collaborations and spin-off activities of the unit. These show that the topics studied within the unit are also very relevant to society and industry. The university demonstrates to be very aware of opportunities for spin-off companies and patents, which was confirmed by the researchers the committee spoke to during the interviews. The committee also judges favourably to the attention and support for outreach activities, of which it heard many examples over the course of the site visit. Overall, the committee was very impressed by the interaction between fundamental research and societal relevance of the unit's research.

### **3.4. Viability**

During the site visit, the committee discussed the plans for the future of the unit with the faculty management. As discussed above, the unit is evidently in an excellent position at the moment, both scientifically and financially. The unit has picked up very well on the recommendation of the previous review committee to generate funding in the second and third stream, which has increased by 50% since the previous review period. According to the committee, the unit is so successful in generating research funds that it is nearing its maximum capacity for efficient handling of personnel and projects in the larger groups. The challenge for the coming years will be to consolidate this position and to keep innovating in new, promising research areas.

In terms of personnel, the unit is well-equipped for the future. It will not see many retirements in the coming years, and has hired some very promising young talent through the tenure track system. The variety in nationality and background of these new hires show that the University of Twente is internationally considered to be an attractive place to work at. As discussed under 3.1, the committee looks favourably to the ambitions of the faculty to recruit new researchers on the level of research clusters rather than the research groups. This broadens the scope towards new emerging research areas to invest in, which is essential for the unit to keep innovating.

The committee in particular considers the area of low power electronics to be a very interesting new area for the unit put efforts in, as was mentioned under 3.2. As an estimate of 15% of the world's energy consumption is already used for IT, techniques for low energy computation are very relevant for the transition towards a sustainable society. The unit is exceptionally well-equipped for this: it houses world-class experts in various experts of nanotechnology (fluid physics, material science), and has the necessary lab facilities in the MESA+ institute. The committee sees great opportunities in this direction and encourages the researchers to continue onto this path. To realize this, theoretical expertise in this field might be necessary. The committee recommends the unit to invest in a tenure tracker on theoretical physics.

In terms of the viability of the unit's infrastructure, the unit is closely tied to the future of the MESA+ facility, which has been a huge investment and continues to require investments for maintenance and use. The committee considers that the university has installed a robust financial structure for these facilities through the institute structure, but that this depends on continued use of the facilities by both researchers and companies to keep these viable. Investing in new research areas such as

the above mentioned low power electronics could safeguard the use of the infrastructure for many years to come. Throughout the interviews, both management and researchers of the unit have expressed their concern for funding of medium-size infrastructure used in basic research. Funding for infrastructures often covers the development of new facilities, but rarely the purchase of commercially-available tools such as advanced lasers or an STM. On the other hand, personal grants do allow for funding equipment, but this is often only sufficient for small-scale equipment and not for expensive equipment. The committee whole-heartedly shares this concern and endorses the attempt of the faculty to lobby for funds to close this gap and dedicate funding for medium-size infrastructure.

Finally, the committee considers the unit to be excellently equipped for the future. It has an excellent funding position and a healthy, very talented research staff from junior to senior level. The faculty management is aware of potential risks concerning the unit's viability, such as the need for continuous innovation in research areas, and the challenge to keep the research infrastructure viable, and takes measures to address these.

### **3.5. PhD programmes**

The PhD candidates the committee met during the site visit came across as very content in their position. They feel welcomed and included in the community, both on a professional and personal level. They experience a lot of freedom to pursue their own interests, cooperate with other groups within the university and with international recognized groups. They feel very well supported by their supervisors and the university. The committee praises the unit for this excellent environment for PhD candidates, in which they are both very satisfied and produce high-quality research.

The Twente Graduate School (TGS) is responsible for the PhD programme of all PhD candidates at the University of Twente. It requires PhD candidates to obtain the equivalent of 30 EC in courses, of which 15 EC is reserved for discipline-related skills and 15 EC for general or professional skills. Activities can be employed at the TGS or associated Research Schools outside the university. These range from writing skills, preparing for and participating in conferences, to Dutch language courses and learning how to launch a spin-off company. The PhD candidates decide together with their supervisors which courses are necessary for the development of the candidate. Part of the courses offered by the TGS are mandatory, such as research ethics and general academic skills. The committee is positive on the Graduate School and the amount of freedom PhD candidates have to use course to shape their own career path as part of their PhD programme, whether they want to pursue careers in academics, industry or as entrepreneur. On the other hand, the committee received signals from individual PhD candidates that not all supervisors are equally committed to the individual PhD programme. It recommends the unit to be on top of this, and secure that all supervisors are aware of their role in co-shaping the PhD programme of their candidates.

The committee found that the unit is very dedicated to have candidates finish their thesis on time. Every PhD candidate devises a PhD development and supervision plan together with his/her supervisor, and progress on this is discussed in regular meetings with the supervisor. After the first year, a formal evaluation takes place in which a 'go / no go' decision is taken for continuation of the PhD trajectory based on performance so far. Some groups take additionally measures to have their PhD candidates finish on time, such as having them write articles that can serve as the body of their thesis as early as the end of their first year and discontinuing their lab space several months before the end of their PhD to allow them to wrap up and finish their writing. In the end, the committee was satisfied with the success rate of the Applied Physics PhD candidates.

During the site visit, the committee discussed the apparent long duration of PhD trajectories that emerged from the provided statistics with management, senior researchers, postdoctoral researchers and PhD candidates. From the numbers in the self-evaluation report, it seemed that less than half of the PhD candidates finish their PhD within four years, with 30% taking five years or longer. During the discussions, it became clear to the committee that this was mostly a distortion of the statistics. PhD trajectories are only counted as completed after the defence, which sometimes takes place



months after actual completion of the thesis. Also, in individual cases PhD candidates find a job before finishing their thesis and as a result are delayed in completion or never finish at all. These cases distort the statistics but are an exception rather than a rule.

### **3.6. Research integrity**

The university has several policies and procedures in place aimed at safeguarding research integrity within the university. This includes a Code of Conduct for Scientific Practice applicable to all researchers, a Scientific Integrity Complaints Procedure to report suspicions of scientific misconduct, and a standard storage system for all data relevant to theses and articles, which is backed-up and maintained by the university. This data is available for anyone upon request.

When discussed during the site visit, research integrity appeared to be well-embedded in the culture of the unit. For instance, all research project proposals with industry pass through a scientific review board, in which they are reviewed on their scientific merit only. This acts as a safeguard against research being steered by industry. Also, all PhD candidates are trained in research ethics as part of the Graduate School courses. The committee noted that this is not necessarily the case for researchers entering the faculty at either postdoctoral or tenure track level. It recommends to include an element of research integrity for all new research personnel as part of their introduction. Ethics, integrity and data management are becoming increasingly important in academics, so continued attention to this aspect is recommendable on all levels of research practice.

### **3.7. Diversity**

The unit strives to be a good reflection of the composition of society within the university. In terms of gender balance, 13% of all research staff members within the unit is female, of which three are group leaders. Although the unit is proud of having increased this number slightly in the past years, it is still below the target of 20% set by all physics departments in the Netherlands. It plans to act on this by aiming at appointing female researchers through the tenure track procedure whenever the opportunity presents itself. The committee agrees that the percentage of women within could be higher, and encourages the unit to continue its efforts to improve this.

The Applied Physics unit at the University has a very international composition, with more than one third of the staff being non-Dutch (of which 60% is European and 40% non-European), more than half of the group leaders and PhD candidates having a foreign nationality. The committee agrees that the unit is very international, and praises its ability to successfully attract and combine such a diverse range of backgrounds within the groups.

### **3.8. Conclusion**

The Applied Physics department conducts world-class research in many aspects. Its researchers are internationally recognized, publish high-quality papers in top-ranking journals and are being recognized with numerous grants and honours. The unit is well equipped with high-class facilities and is working on topics that are very relevant to society. It has a wide range of cooperation with industry and has succeeded in attracting many external funds. The committee liked the interaction between fundamental research and societal relevance. The unit has a solid PhD programme in place and pays attention to issues of research integrity. The composition of the research staff is very international. The gender balance could be improved, an issue of which the faculty is aware and is taking measures for improvement.

The unit has a clear vision of what it wants to achieve in the future, and is well-equipped to pursue these goals. The management is aware of opportunities and weaknesses, and is working hard to remedy them. The tenure track system is a very strong way of incorporating new researchers and research lines into the faculty. The cluster structure recently introduced at the faculty helps to bring focus to the priority areas of the unit, and gives the topics critical mass to undertake bigger projects. By discussing new tenure track positions in the clusters, the faculty is able to take a broader perspective and take new opportunities in emerging topics that might have been outside the scope of the smaller research groups. It also stimulates multidisciplinary research, as groups from other



units and sometimes also outside the faculty meet each other in the clusters. The research institutes are then helpful to deal with even larger projects such as managing and maintaining the big facilities. Structural funding of the facilities and medium-scale equipment is a future threat, and the committee fully supports this concern of the faculty and stimulates the management to address these issues to higher level decision makers. Fundamental research using this equipment is of high importance to the development of science and society.

***Overview of the quantitative assessment***

Research quality:	excellent
Relevance to society:	excellent
Viability:	excellent

## 4. RECOMMENDATIONS

Considering the SEP evaluation protocol and the Terms of Reference provided by the University of Twente, the committee recommends the discipline of Applied Physics to:

- continue to develop the research clusters in order to become internationally competitive units. It encourages the cooperation between research groups to support the smaller groups within the unit and to promote even further their international visibility;
- hire tenure track researchers on the level of the research clusters rather than the research groups in order to encourage research groups to think about new tenure track positions in terms of emerging topics and challenges;
- expand on and invest in the emerging topic of low power electronics, and to consider hiring a theoretical physicist in this area;
- aim at consolidation of the current size of the large research groups rather than to aim for further expansion to keep these groups manageable;
- lobby for new funding tools for the funding of medium-sized equipment and infrastructure;
- secure that all PhD supervisors are aware of their role in co-shaping the PhD programme of their PhD candidates;
- pay attention to research integrity, ethics and data management for new research staff on all levels rather than only PhD candidates;
- continue efforts to improve the gender balance within the unit.



# APPENDICES



## APPENDIX 1: THE SEP CRITERIA AND CATEGORIES

There are three criteria that have to be assessed:

- Research quality:
  - Level of excellence in the international field;
  - Quality and scientific relevance of research;
  - Contribution to body of scientific knowledge;
  - Academic reputation;
  - Scale of the unit's research results (scientific publications, instruments and infrastructure developed and other contributions).
  
- Relevance to society:
  - quality, scale and relevance of contributions targeting specific economic, social or cultural target groups;
  - advisory reports for policy;
  - contributions to public debates.

The point is to assess contributions in areas that the research unit has itself designated as target areas.

- Viability:
  - the strategy that the research unit intends to pursue in the years ahead and the extent to which it is capable of meeting its targets in research and society during this period;
  - the governance and leadership skills of the research unit's management.

Category	Meaning	Research quality	Relevance to society	Viability
1	World leading/excellent	The unit has been shown to be one of the most influential research groups in the world in its particular field.	The unit makes an outstanding contribution to society	The unit is excellently equipped for the future
2	Very good	The unit conducts very good, internationally recognised research	The unit makes a very good contribution to society	The unit is very well equipped for the future
3	Good	The unit conducts good research	The unit makes a good contribution to society	The unit makes responsible strategic decisions and is therefore well equipped for the future
4	Unsatisfactory	The unit does not achieve satisfactory results in its field	The unit does not make a satisfactory contribution to society	The unit is not adequately equipped for the future



## APPENDIX 2: PROGRAMME OF THE SITE VISIT

### **Sunday March 25, 2018**

19:00 *Informal committee dinner (private)*

### **Monday March 26, 2018**

09:45 - 10:15 Word of welcome by the Rector

10:15 - 12:15 *Presentation QANU, preparation interviews (private)*

12:15 - 13:15 Lunch with PhD candidates

13:15 - 14:00 Presentation and first interview faculty board

14:00 - 15:30 Lab Tour

15:30 - 16:00 *Tea break, wrap-up time (private)*

16:00 - 17:15 Interviews HL, incl. short presentations 4 HL

17:15 - 17:30 *Wrap-up time (private)*

17:30 - 18:15 Interviews tenure trackers

18:15 - 21:00 *Discussion over dinner (private)*

### **Tuesday March 27, 2018**

08:45 - 09:15 *Preparation interviews (private)*

09:15 - 10:00 Interviews PhDs and postdocs

10:00 - 10:15 *Wrap-up time (private)*

10:15 - 10:45 Second interview faculty board

10:45 - 11:15 *Coffee break, wrap up time (private)*

11:15 - 12:15 *Discussing and writing preliminary judgments (private)*

12:15 - 12:45 *Time for additional discussions*

12:45 - 13:45 *Lunch (private)*

13:45 - 14:15 Presentation first impressions by Committee chair

14:15 Departure committee

discipline = all of the discipline, including dean and chair.

faculty board = MT members of TNW

HL = full professors of the discipline

## APPENDIX 3: QUANTITATIVE DATA

### Applied Physics research staff (#)

	2010	2011	2012	2013	2014	2015	2016
Scientific staff	43,3	52,3	54,0	56,4	61,2	59,1	60,8
postdocs	66,2	52,8	56,5	59,8	60,8	71,2	66,7
PhD students	115,5	140,7	145,0	153,5	160,2	173,4	157,2
<b>Total staff</b>	<b>224,9</b>	<b>245,8</b>	<b>255,5</b>	<b>269,7</b>	<b>282,2</b>	<b>303,8</b>	<b>284,7</b>

### Applied Physics research staff (fte)

	2010	2011	2012	2013	2014	2015	2016
Scientific staff	34,3	38,0	40,0	41,2	44,8	45,3	43,7
postdocs	44,3	40,8	41,9	40,2	43,6	52,7	45,0
PhD students	93,2	110,0	125,2	129,6	132,2	141,0	132,6
<b>Total staff</b>	<b>171,7</b>	<b>188,8</b>	<b>207,1</b>	<b>211,0</b>	<b>220,5</b>	<b>238,9</b>	<b>221,3</b>

### Research output

<i>Publication category*</i>	2010	2011	2012	2013	2014	2015	2016
Refereed articles	222	254	238	253	221	240	249
Book chapters	6	8	3	7	8	11	4
PhD theses UT	16	17	22	21	26	37	31
PhD theses external	3	9	2	5	3	3	3
Professional publications	0	1	4	2	0	0	0
Patents	8	11	19	5	3	4	10
<b>Total publications</b>	<b>255</b>	<b>300</b>	<b>288</b>	<b>293</b>	<b>261</b>	<b>295</b>	<b>297</b>

\* Numbers represent single publications, corrected for joint publications and dissertations

### Research funding

	2010	2011	2012	2013	2014	2015	2016
<i>Funding (M€/%)</i>							
Direct funding (1)	13,7 / 65%	13,8 / 61%	12,8 / 55%	12,4 / 54%	12,9 / 50%	13,6 / 53%	13,7 / 54%
Research funds (2)	4,0 / 19%	5,9 / 27%	7,1 / 30%	6,6 / 29%	7,8 / 30%	7,4 / 29%	6,1 / 24%
Contracts (3)	3,3 / 16%	2,6 / 12%	3,4 / 14%	4,0 / 18%	5,1 / 20%	4,6 / 18%	5,6 / 22%
<b>Total funding</b>	<b>21,0</b>	<b>21,8</b>	<b>23,3</b>	<b>23,0</b>	<b>25,9</b>	<b>25,6</b>	<b>25,4</b>
<i>Expenditure (M€/%)</i>							
Personnel costs	12,1/ 58%	12,6 / 58%	13,6 / 58%	13,6 / 59%	13,8 / 53%	15,8 / 62%	15,2 / 60%
Other costs	6,7 / 32%	6,9 / 32%	7,4 / 32%	7,0 / 30%	9,6 / 37%	7,2 / 28%	7,7 / 30%
Housing	2,2 / 11%	2,2 / 10%	2,3 / 10%	2,4 / 11%	2,5 / 10%	2,6 / 10%	2,4 / 10%
<b>Total expenditure</b>	<b>21,0</b>	<b>21,8</b>	<b>23,3</b>	<b>23,0</b>	<b>25,9</b>	<b>25,6</b>	<b>25,4</b>

