MASTER’S PROGRAMME PHYSICS

FACULTY OF SCIENCE

LEIDEN UNIVERSITY

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This report was finalised on 23 September 2019

REPORT ON THE MASTER'S PROGRAMME PHYSICS OF LEIDEN UNIVERSITY

This report takes the NVAO's Assessment Framework for the Higher Education Accreditation System of the Netherlands for limited programme assessments as a starting point (September 2018).

ADMINISTRATIVE DATA REGARDING THE PROGRAMME

Master's programme Physics

Name of the programme:	Physics
CROHO number:	60202
Level of the programme:	master's
Orientation of the programme:	academic
Number of credits:	120 EC
Specialisations or tracks:	- Research in Physics: Theory - Research in Physics: Biological and Soft Matter Physics (BSM) - Research in Physics: Quantum Matter & Optics (QMO) - Research in Physics: Cosmology - Research in Physics: Casimir pre-PhD - Physics and Science Based Business (SBB) - Physics and Science Communication and Society (SCS) - Physics and Education (EDU)
Location:	Leiden
Mode of study:	full time
Language of instruction:	English
Submission deadline NVAO:	01/11/2019

The visit of the assessment panel Physics and Astronomy to the Faculty of Science of Leiden University took place on 23 and 24 April 2019.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

Name of the institution:	Leiden University
Status of the institution:	publicly funded institution
Result institutional quality assurance assessment:	positive

COMPOSITION OF THE ASSESSMENT PANEL

The NVAO has approved the composition of the panel on 1 February 2019. The panel that assessed the master's programme Physics consisted of:

- Prof. dr. R. (Reinder) Coehoorn, full professor at the Eindhoven University of Technology on the Physics and Application of Nanosystems. He is affiliated to the research group Molecular Materials and Nanosystems at the Department of Applied Physics [chair];
- Prof. dr. M.J. (Margriet) Van Bael, professor at the Department of Physics and Astronomy of the Faculty of Science of KU Leuven (Belgium);
- Prof. dr. G. (Garrelt) Mellema, professor and programme director at the Department of Astronomy of Stockholm University (Sweden);

- Prof. dr. S. (Sjoerd) Stallinga, professor and head of the Department Imaging Physics of Delft University of Technology;
- L. (Laura) Scheffer BSc, master's student Physics at Utrecht University [student member].

The panel was supported by P. (Peter) Hildering MSc, who acted as secretary.

WORKING METHOD OF THE ASSESSMENT PANEL

The master's programme Physics at the Faculty of Science of Leiden University was part of the cluster assessment Physics and Astronomy. Between April 2019 and June 2019 the panel assessed 17 programmes at 5 universities.

Panel members
The panel consisted of the following members:
- Prof. dr. R. (Reinder) Coehoorn, full professor at the Eindhoven University of Technology on the Physics and Application of Nanosystems. He is affiliated to the research group Molecular Materials and Nanosystems at the Department of Applied Physics [chair];
- Prof. dr. M.J. (Margriet) Van Bael, professor at the Department of Physics and Astronomy of the Faculty of Science of KU Leuven (Belgium);
- Prof. dr. H.A.J. (Harro) Meijer, professor of Isotope Physics, chairman of the Centrum voor Isotopen Onderzoek (CIO) and director of the Energy and Sustainability Research Institute Groningen at University of Groningen;
- Prof. dr. G. (Garrelt) Mellema, professor and programme director at the Department of Astronomy of Stockholm University (Sweden);
- Prof. dr. S. (Sjoerd) Stallinga, professor and head of the Department Imaging Physics of Delft University of Technology;
- Prof. dr. G. (Geert) Vanpaemel, professor for History of Science and Science Communication at KU Leuven, Belgium;
- J. (Jeffrey) van der Gucht BSc, master's student Physics and Astronomy at Radboud University [student member];
- B. N. R. (Bram) Lap BSc, master's student Astronomy at University of Groningen [student member];
- L. (Laura) Scheffer BSc, master's student Physics at Utrecht University [student member].

For each site visit, assessment panel members were selected based on their expertise, availability and independence.

The QANU project manager for the cluster assessment was Peter Hildering MSc. He acted as secretary in the site visit of Leiden University and Utrecht University. In order to assure the consistency of assessment within the cluster, the project manager was present at the panel discussion leading to the preliminary findings at all site visits and reviewed all draft reports. Dr. Barbara van Balen acted as secretary in the site visits of University of Groningen and the joint degrees in Amsterdam. Drs. Mariëtte Huisjes was secretary at Radboud University. The project manager and the secretaries regularly discussed the assessment process and outcomes.

Preparation
On 24 January 2019 the panel chair was briefed by the project manager on the tasks and working method of the assessment panel and more specifically his role, as well as use of the assessment framework.

A preparatory panel meeting was organised on 15 March 2019. During this meeting, the panel members received instruction on the tasks and working method and the use of the assessment framework. The panel also discussed their working method and the domain specific framework.

A schedule for the site visit was composed. Prior to the site visit, representative partners for the various interviews were selected. See Appendix 4 for the final schedule.

Before the site visit, the programmes wrote self-evaluation reports of the programmes and sent these to the project manager. He checked these on quality and completeness, and sent them to the panel members. The panel members studied the self-evaluation reports and formulated initial questions and remarks, as well as positive aspects of the programmes.

The panel also studied a selection of theses. The panel studied the work and the assessment forms of 9 students, based on a provided list of graduates between 2016-2018. Four of these students wrote a double thesis, so the total number of theses studied was 13. For this selection, the panel used the opportunity to select a lower number of theses as described in the NVAO framework when there is significant overlap between the assessed programmes in a single site visit. In the case of the master's programme Physics, this overlap consists of a shared Board of Examiners with the bachelor's programme Physics, as well as alignment of assessment procedures with the Astronomy Board of Examiners and internal benchmarking through an overlap of teaching staff with the other programme's in the assessment. A variety of topics and tracks and a diversity of examiners were included in the selection. The project manager and panel chair assured that the distribution of grades in the selection matched the distribution of grades of all available theses.

Site visit
The site visit to Leiden University took place on 23 and 24 April 2019.

At the start of the site visit, the panel discussed its initial findings on the self-evaluation reports and the theses, as well as the division of tasks during the site visit.

During the site visit, the panel studied additional materials about the programmes and exams, as well as minutes of the Programme Committee and the Board of Examiners. An overview of these materials can be found in Appendix 5. The panel conducted interviews with representatives of the programmes: students and staff members, the programme's management and representatives of the Board of Examiners. It also offered students and staff members an opportunity for confidential discussion during a consultation hour. No requests for private consultation were received.

The panel used the final part of the site visit to discuss its findings in an internal meeting. Afterwards, the panel chair publicly presented the panel's preliminary findings and general observations.

Report
After the site visit, the secretary wrote a draft report based on the panel's findings and submitted it to the project manager for peer assessment. Subsequently, the secretary sent the report to the panel. After processing the panel members' feedback, the project manager sent the draft reports to the faculty in order to have these checked for factual irregularities. The project manager discussed the ensuing comments with the panel's chair and changes were implemented accordingly. The report was then finalised and sent to the Faculty of Science and University Board.

Definition of judgements standards
In accordance with the NVAO's Assessment framework for limited programme assessments, the panel used the following definitions for the assessment of the standards:

Generic quality
The quality that, from an international perspective, may reasonably be expected from a higher education Associate Degree, Bachelor's or Master's programme.

Meets the standard
The programme meets the generic quality standard.

Partially meets the standard
The programme meets the generic quality standard to a significant extent, but improvements are required in order to fully meet the standard.

Does not meet the standard
The programme does not meet the generic quality standard.

The panel used the following definitions for the assessment of the programme as a whole:

Positive
The programme meets all the standards.

Conditionally positive
The programme meets standard 1 and partially meets a maximum of two standards, with the imposition of conditions being recommended by the panel.

Negative
In the following situations:
- The programme fails to meet one or more standards;
- The programme partially meets standard 1;
- The programme partially meets one or two standards, without the imposition of conditions being recommended by the panel;
- The programme partially meets three or more standards.

SUMMARY JUDGEMENT

The master's programme Physics convincingly profiles itself as a strong, research-oriented core programme in Physics. The education is closely related to the excellent research environment of the LION Institute and aims to educate students to meet the need for disciplinary specialists in physics with solid academic and research skills. The intended learning outcomes are aligned with the expectations of the academic and professional field through a European domain-specific reference framework, and are fitting for an academic master's programme in terms of level and orientation. The panel recommends checking the intended learning outcomes for each specialisation, and marking any non-applicable learning outcomes for individual specialisations.

The teaching-learning environment of the programme facilitates students to achieve the intended learning outcomes. The specialisations offer students the opportunity to deepen their knowledge and skills in physics, and engage themselves in research at the frontiers of physics. The students are offered a large amount of flexibility and choice to compose their own curriculum. The programme provides students with close guidance and coaching throughout their curriculum, assisting them to compose a feasible and coherent programme. The panel recommends that the programme explore possibilities to connect better with the society-oriented specialisations, in order to provide students who choose these specialisations with a more coherent programme.

The fact that students are embedded in the institute, in particular in the second year of their master's programme where they work in a master-apprentice relationship in a research group, offers them hands-on experience in research and skills, fitting the goals of the programme. The panel approves the 'double thesis' philosophy of the programme, which it considers a good learning experience for students. The use of English as the language of instruction fits the international character of the field. The teachers of the programme are experts in their field and very well equipped to help students become acquainted with research. The panel recommends that the programme encourage students to complete their research projects in time, for instance by adding time management as an assessable skill to the projects.

The master's programme Physics has an adequate assessment system that assesses students on all intended learning outcomes. The assessment methods are varied and fit the programme's goals. A quality assurance system with a peer-review principle applied to all exam questions and the assessment of the master's project enhances the validity and transparency of student assessment. The panel advises better monitoring of the compliance with completing the assessment forms and the designing of separate rubrics for the bachelor's and master's projects. The Board of Examiners adequately fulfils its role in the quality assurance of assessment, but could take a more proactive and normative stance towards the programme management. The panel recommends investigating options for more involvement in the assessment of the society-oriented specialisations, for instance by providing second examiners for projects.

The panel concludes that the final projects of the master's programme Physics are of a good quality, and convincingly show that the intended learning outcomes of the programme are achieved by the students. The individual embedding of students in a research group and their training by active researchers was clearly reflected in the high quality of the works, which showed good academic and research skills. This is further demonstrated by the high number of alumni who start a PhD and the excellent job perspectives of all alumni.

The panel assesses the standards from the *Assessment framework for limited programme assessments* in the following way:

Master's programme Physics

Standard 1: Intended learning outcomes	meets the standard
Standard 2: Teaching-learning environment	meets the standard
Standard 3: Student assessment	meets the standard
Standard 4: Achieved learning outcomes	meets the standard
General conclusion	positive

The chair of the panel, prof. dr. Reinder Coehoorn, and the secretary, Peter Hildering MSc, hereby declare that all panel members have studied this report and that they agree with the judgements laid down in the report. They confirm that the assessment has been conducted in accordance with the demands relating to independence.

Date: 23 September 2019

DESCRIPTION OF THE STANDARDS FROM THE ASSESSMENT FRAMEWORK FOR LIMITED FRAMEWORK ASSESSMENTS

Standard 1: Intended learning outcomes
The intended learning outcomes tie in with the level and orientation of the programme; they are geared to the expectations of the professional field, the discipline, and international requirements.

Findings

The master's programme Physics of Leiden University is, alongside the bachelor's programme Physics, organised by the Leiden Instituut voor Onderzoek in de Natuurkunde (LION; Leiden Institute of Physics), which is part of the Faculteit Wiskunde en Natuurwetenschappen (FWN; Faculty of Science) of Leiden University. LION cooperates closely with the Leidse Sterrewacht [observatory], the FWN institute that offers the related bachelor's and master's programmes in Astronomy. The programme offers five research-oriented specialisations: Theory, Biological and Soft Matter Physics (BSM), Quantum Matter & Optics (QMO), Cosmology, and the Casimir pre-PhD. The latter is jointly organised with TU Delft and specifically prepares students for a PhD programme at either Leiden or Delft.

Additionally, the programme offers students the opportunity to participate in one of three society-oriented specialisations: Science-Based Business (SBB), Science Communication and Society (SCS) and Education (EDU). These are faculty-wide specialisations in which students from all the faculty's master's programmes can participate.

Vision and profile
The programme aims to educate its students to be competitive in international research or in the broader knowledge-based job market. Compared to the bachelor's programme, this requires deepening of knowledge and skills and active knowledge of frontier research in specific areas of physics, as well as professional competences such as learning ability, management skills and independence. The programme views itself as research-oriented, with a strong emphasis on becoming acquainted with the daily research practice and academic skills. Within the research specialisations, the programme offers its students the opportunity to shape their own curriculum based on their interests in either experiments or theory, or a mixture of both. In line with the research focus of LION, the programme is strong in the areas of cosmology, quantum matter and optics, soft-matter physics and biophysics. Students are typically embedded within a LION research group for their research assignments and, as a result, are trained on the job by experts in the field.

The panel recognises the vision and profile as described by the programme. The programme has a clear focus on a strong core physics curriculum, extended by a sufficiently wide selection of specialisation courses and electives. It offers ample opportunities for tailoring to the interests of the individual students in the context of an excellent research environment. During the site visit, the panel spoke with the programme about the choice to focus on a core disciplinary physics programme in terms of the scientific grand challenges, such as energy and sustainability, which require a multidisciplinary approach. The programme explained that this is a deliberate choice. A successful multidisciplinary team not only requires multidisciplinary researchers, specialised disciplinary researchers must also be able to cooperate. LION aims to deliver these specialists through offering students a core curriculum, while at the same time providing room for multidisciplinary approaches in electives and specialisation courses. The panel subscribes to this vision and deems the programme's choice in this aspect appropriate, and fitting to the needs of the field.

Intended learning outcomes
The programme derived its intended learning outcomes from the domain-specific reference framework Physics (Appendices 1 and 2). This framework, which is used by all Physics and Astronomy programmes in the Netherlands, is the international standard for programmes within the field, and was developed in a joint process at the European level (Tuning Physics) to align the Physics and Astronomy programmes at an international level. These intended learning outcomes use the Dublin descriptors to describe knowledge, insights and skills that each master's student in either Physics or Astronomy should achieve, regardless of his or her specialisation. Additionally, the programme uses six final qualifications defined by the faculty FWN for all of its master's students. The three society-oriented specialisations have a set of additional qualifications for their students to achieve.

The programme presented the panel with an overview in which the domain-specific and faculty-wide intended learning outcomes were linked through the Dublin descriptors to form a coherent set. The panel studied this overview and deems these two sets of learning outcomes appropriate and insightful for a Physics programme at a master's level. The academic orientation and master's level are clearly visible through the link with the Dublin descriptors. The panel is positive about the alignment of the Physics and Astronomy programmes at a European level, and thinks that this advances the broad recognition of the knowledge, insights and skills acquired by the students by both the academic and the professional field.

In terms of the content of the intended learning outcomes, the panel notes that they do not apply equally to all research specialisations. For instance, learning outcome B4 ('be able to perform experiments independently…') does not apply to the Theory specialisation, in which experiments are not part of the curriculum. The panel recommends checking the intended learning outcomes with the content of each individual specialisation, and making any deviations at the level of the specialisations visible in the formulation of the intended learning outcomes.

Considerations

The master's programme Physics convincingly profiles itself as a strong, research-oriented core programme in Physics. The education is closely related to the excellent research environment of the LION Institute and aims to educate students to meet the need for disciplinary specialists in physics with solid academic and research skills. The intended learning outcomes are aligned with the expectations of the academic and professional field through a European domain-specific reference framework, and are fitting for an academic master's programme in terms of level and orientation. The panel recommends checking the intended learning outcomes for each specialisation, and marking any non-applicable learning outcomes for individual specialisations.

Conclusion
Master's programme Physics: the panel assesses Standard 1 as 'meets the standard'.

Standard 2: Teaching-learning environment The curriculum, the teaching-learning environment and the quality of the teaching staff enable the incoming students to achieve the intended learning outcomes.

Findings

Curriculum
The 120 EC master's programme Physics consists of a small core of mandatory courses (15 EC), plus a combination of core courses, electives and research projects specific for the selected specialisation. The mandatory courses on Quantum theory, Statistical physics, and Academic and professional skills guarantee that all students acquire a sufficient level in physics and skills, regardless of their specialisation. The programme offers five research specialisations, each with their own distribution of EC over core courses, electives and research projects. These are Theory, Biological and Soft Matter

Physics (BSM), Quantum Matter & Optics (QMO), Cosmology, and the Casimir pre-PhD. The first four specialisations align with the research focus areas of the LION Institute, while the Casimir pre-PhD serves as an honours programme that is aimed at preparing students for a PhD programme at either Leiden or Delft. Students are selected after they complete the first semester, and need a grade average of at least 7.5 on mandatory physics courses. The Cosmology specialisation has a close connection to and overlap with the specialisation of the same name in the master's programme Astronomy, although it differs in two mandatory courses that are more physics rather than astronomy focused.

Typically, the first year comprises core courses and/or electives within the specialisation, and the second year is dedicated to two smaller research projects in one of the groups that organises the specialisation (BSM, QMO, Cosmology). By having students conduct a 'double thesis', the programme aims to expose them to a larger variety of research and training by different researchers from different groups. Due to their nature, the Theory and Casimir specialisations deviate from this approach. The Theory specialisation requires students to dig deeper into a subject and therefore offers a single large research project, and the Casimir pre-PhD students do one larger project combined with two smaller projects and the writing of a research proposal to compete for PhD funding.

Each specialisation has a lot of room to adapt the programme to the personal preferences and interests of the individual student. A major part of the curriculum (27 EC for Cosmology, 42 EC for Theory and 45 EC for BSM, QMO and Casimir) is reserved for electives. At the start of their studies, students compose a personal study plan with the study advisor, based on the courses and research projects offered by the research group(s) in which he or she will be embedded during the master's programme. The study advisor ensures the coherence and feasibility of the individual curriculum. The connection of this curriculum to the programme's intended learning outcomes is covered through the mandatory courses, the research projects and the skills that students acquire by being embedded in a research environment.

The panel studied the curriculum of the programme and the content of the specialisations, and feels that they offer students the opportunity to deepen their knowledge and skills in physics, and engage themselves in research at the frontiers of physics. It values the amount of flexibility and choice offered to the students to compose their own curriculum. The fact that students are embedded in the institute, in particular in the second year of their master's programme where they work in a master-apprentice relationship in a research group, offers them hands-on experience in research and skills, fitting the goals of the programme. The panel approves the 'double thesis' philosophy of the programme. It thinks that experiencing a diversity in topics and approaches is a good learning experience for students.

Society-oriented specialisations
Students who participate in one of three society-oriented specialisations follow an adapted curriculum. They carry out a 36 EC physics research project in the first year, alongside the mandatory core courses and 9 EC of electives. The second year is fully dedicated to the courses in Science-Based Business (SBB), Science Communication and Society (SCS) or Education (EDU). These are faculty-wide specialisations in which students from all the faculty's master's programmes can participate. The research project counts as the thesis for the master's programme Physics, while the specialisation is completed by either an internship (SBB, SCS) or teaching practice (EDU). A small number of Physics students enrol in one of these specialisations each year.

The panel studied the way in which the society-oriented specialisations are embedded in the master's programme Physics, specifically the SBB specialisation due to very low student numbers from Physics in the other specialisations. It read a number of internship reports for the SBB specialisation and spoke to the SBB programme director. It deduced from this that there is hardly any cross-fertilisation between the physics part and the business-oriented part of the programme: physics students follow the same curriculum as biology or chemistry students enrolled in the specialisation. The specialisations are organised by a separate department within the faculty, to which all education within the specialisations is mandated. The SBB internships report paint the same picture: students do not seem encouraged to connect their science-based business skills and knowledge with their physics background. The panel thinks that this is a missed opportunity, as there are many possible connections between physics and science-based business that would make the two curricula more than the sum of their parts. It recommends that the programme explore possibilities to connect better with the society-oriented specialisations, in order to provide students who choose these specialisations with a more coherent programme.

Didactics
The master's programme mostly consists of small-scale courses offered within the specialisations, which are typically attended by 10-20 students. Most courses are taught as lecture series based on the research literature, to which students contribute with mini-project presentations. Due to the small number of students, these courses are usually highly interactive. According to the programme, the main didactical approach is the embedding of students within the research institute and supervision by experienced researchers. The programme aims for its students to learn by experiencing a high-quality research environment, and doing projects supervised by active researchers.

Students indicated to the panel that they very much enjoy this experience, and that they feel treated as an equal in the research groups, participating in activities and engaging with researchers and professors in interesting discussions. They utilise the facilities of the research groups, and can use a desk with PC, lab space and access to common facilities. The panel is positive about the didactics of the programme, and thinks that learning by experiencing and being supervised by experts is fitting for a research-oriented master's programme.

Language and internationalisation
The teaching language of the programme is English, which is the common language for research in the natural sciences, and therefore essential for a research-oriented programme. As active researchers in the field, all the teaching staff has sufficiently mastered the English language. The panel fully supports the use of English in this master's programme, and thinks that this is the obvious choice in light of the programme's goals.

The programme aims for an international classroom within the programme in order to reflect the international character of the field. Approximately one-third of the current student population is non-Dutch, and this number has been rising in recent years. A major part of the teaching staff is also non-Dutch, which adds to the international character of the programme. The programme is satisfied with the percentage of international students and sees 50-50 as the maximum ratio. It would welcome some more diversity in the cultural background of the students, as the majority of international students are currently from within the EU. For students with a non-Dutch bachelor's degree applying to the programme, a Board of Admissions evaluates their degree and the equivalence of the degree to a Leiden bachelor's degree in Physics to decide whether this provides enough confidence that the candidate will be able to complete the master's programme. If there are deficiencies, students can be asked to eliminate them in a pre-master's programme with a maximum of 60 EC.

The programme facilitates international students by helping them find housing, which is currently a major challenge in the Leiden region, and invests in a quick embedding within the institute through social events and a buddy system. This system pairs international students with a local student who can help them find their way. The international students whom the panel spoke to felt welcomed within the programme and were pleased with the accessibility of their teachers and the small-scale character of the programme. The panel thinks that the level of internationalisation fits the goals of the programme and praises the programme for the attention paid to the integration of international students.

Feasibility
Since the majority of the programme is customised, students have a large amount of control over the structure of their personal curriculum. The study advisor plays a major role in helping them construct a feasible curriculum. At the start of their studies, the study advisor helps each student set up a study plan, detailing the courses and research projects the student intends to do. During their studies, the study advisor keeps monitoring the students' progress and advises on and approves modifications of the study plan if necessary. During their research project(s), students are monitored by their supervisor, who is a researcher within the institute students are embedded in. This is usually a close relationship in which they are actively coached throughout their project in frequent meetings.

Students are generally satisfied with the feasibility of their curriculum, although some indicate that issues with scheduling and/or admission criteria of courses can hinder them in constructing their ideal curriculum. The panel thinks that this is an inescapable consequence of such a flexible programme and is convinced that the programme tries its best to prevent these issues as much as possible, which it encourages the programme to keep doing. It praises the personal attention and guidance given to students by the study advisor, and thinks that this is a very good service for students.

The panel notes that approximately 50% of the students need more than two years to complete their master's programme. When discussing this during the site visit, staff and students indicated that this can mostly be attributed to students taking longer to finish their research projects. The panel thinks that students could benefit from stricter guidelines for the timely completion of research projects. The programme could, for instance, include time management as an assessable skill on research projects, and help students in training this essential research skill during their project.

Teaching staff
The teaching staff within the programme are associated with the LION Institute, or in some cases with one of the other institutes at FWN, or at TU Delft in the case of the Casimir specialisation. All of them have obtained a PhD and are employed at LION in a permanent or tenure-track position. Obtaining a Basic Qualification in Teaching (BKO) has been a prerequisite for every new teacher since 2008, and 90% of the programme's teachers currently have a BKO. The programme and faculty organise at least four thematic meetings on education per year. Each teacher typically teaches 1-2 courses per year, and changes courses every four years. The programme put this mechanism in place to prevent courses from becoming stale, and to keep its teachers challenged. The teaching staff support this philosophy, and feel challenged to keep their courses fresh. All teachers in the master's programme are active researchers in a research institute that was ranked excellent on research quality in the last research evaluation. The teaching staff includes several top researchers, including four recipients of the Spinoza Prize, the highest individual research award in the Netherlands.

Students are very enthusiastic about their teachers, and feel incorporated in the small-scale programme with very approachable staff. They feel that their teachers put a lot of effort into teaching and are always prepared to make an extra effort to help students. The panel supports this view. As active researchers in the field in an excellent research institute, the teaching staff is very well equipped to guide students to develop their research skills. It also deems the periodic changes in teaching staff within the courses a good measure to keep the courses fresh and up-to-date. According to the panel, the support of the teaching staff for this mechanism underlines the value that the teaching staff attaches to education.

Considerations

The teaching-learning environment of the programme facilitates students to achieve the intended learning outcomes. The specialisations offer students the opportunity to deepen their knowledge and skills in physics, and engage themselves in research at the frontiers of physics. The students are offered a large amount of flexibility and choice to compose their own curriculum. The programme provides students with close guidance and coaching throughout their curriculum, assisting them to compose a feasible and coherent programme. The panel recommends that the programme explore possibilities to connect better with the society-oriented specialisations, in order to provide students who choose these specialisations with a more coherent programme.

The fact that students are embedded in the research groups throughout the course of their master's programme in a master-apprentice relationship offers them hands-on experience in research and skills, fitting the goals of the programme. The panel approves the 'double thesis' philosophy of the programme, which it considers a good learning experience for students. The use of English as the language of instruction fits the international character of the field. The teachers of the programme are experts in their field and very well equipped to help students become acquainted with research. The panel recommends that the programme encourage students to complete their research projects in time, for instance by adding time management as an assessable skill to the projects.

Conclusion
Master's programme Physics: the panel assesses Standard 2 as 'meets the standard'.

Standard 3: Student assessment
The programme has an adequate system of student assessment in place.

Findings

Assessment system
The programme assesses the knowledge, understanding and skills of students in various ways. The common denominator is a written exam with open questions at the end of the course, supplemented with homework exercises, student presentations or an occasional mid-term exam or essay. The written exam usually determines 40-60% of the grade. The quality of the exam questions and answers is checked beforehand by a second reader in terms of clarity, length, level and coverage of the course materials. Other assessment forms include class participation as demonstrated by presentations and homework assignments, essays or computer programmes. The assessment methods are designed to collectively assess all essential skills, such as presenting, writing and independent research.

The panel studied the assessment system of the programme, an overview of the assessment methods and criteria per course, and some examples of exams used within the programme. It approves the variety of assessment methods and the attention paid to the assessment of various research skills within the programme, which fits the programme's goals. The independent check of all exam questions by the second reader is a good method to increase the validity of the exams.

Assessment research projects
Students conclude the programme with either one or two research projects, depending on their track. During these projects, they are embedded within one of LION's research groups. They select their own topic in consultation with their supervisor. Additionally, they need the consent of the study advisor, who checks whether the content and methodology of the project aligns with the programme's intended learning outcomes and the student's individual curriculum. Upon completion of the project, the final grade is determined by two independent examiners: the daily supervisor and an independent second examiner from another research group. The assessment focuses on three aspects: research, thesis and oral presentation. The two examiners decide collectively on a grade on all three aspects, and substantiate and register this on an assessment form. If the two examiners cannot agree on a grade, the grade will be the average of the grades of both examiners. Every thesis is checked for plagiarism using the Turnitin software, and is stored online in a thesis archive. The assessment form was redesigned in 2018, and consists of seven criteria that assessors can grade using a rubric. This redesign was aimed at improving the uniformity of the assessments.

The panel thinks that the assessment procedure for research projects is adequate. The independent second reader increases the validity of the grading. The panel studied a number of old and new assessment forms as part of the thesis check conducted prior to the site visit. It concluded that the current assessment form makes a better distinction between research, thesis and oral presentation, and provides better insight into the composition of the final grade. It notes that a number of assessment forms could be improved in terms of transparency, as they fully or partially lacked qualitative feedback. This also affects the students involved, as they do not have a written motivation of the feedback on their work. The programme management and Board of Examiners stated that this is not intentional, and that it is standing policy that all forms should contain sufficient written feedback. The panel advises the programme to enforce this.

The panel noted that the programme uses the same assessment form as the bachelor's programme Physics. The programme commented that examiners are responsible for grading master's students on stricter criteria, but also admitted that it is not fully satisfied with this situation and would like to introduce two different forms. The panel encourages the programme to carry out these plans. The bachelor's and master's projects have separate goals and should not be assessed on the same criteria. It advises the programme to differentiate between the two programmes and to change the assessment form accordingly.

Board of Examiners
The master's programme Physics shares a Board of Examiners with the bachelor's programme Physics. This Board has four members from the programmes and one external member. The Board appoints the programme's examiners and monitors the quality of assessment within the programme. It performs systematic checks of the exams within the programme in terms of coverage of the course's learning goals and the validity and transparency of the exam. Each course is checked approximately once every four years. The Board conducts these checks itself, assisted if necessary by additional experts. The Board has not found any major shortcomings in the programme's assessment in the past years. A sample of master's projects is checked annually for adequate grading. Recently, the Board noted that the grades in the programme were quite high, which has led to the introduction of the rubric mentioned above to harmonise the grading. For the society-oriented specialisations, the faculty has mandated two dedicated Boards of Examiners: one for the educational specialisation and one for the business and communication specialisations. These Boards take care of the quality of assessment within these specialisations. Formally, the Physics Board of Examiners has mandated its responsibility for these three variants to these specialisation-specific Boards. These Boards report back annually to the Physics Board of Examiners, or when issues require a direct response.

The panel spoke to the Board of Examiners, including one member of the Communication and Business mandated Board, and studied a number of the Board's annual reports. It judges that the Board adequately fulfils its role in the quality assurance of assessment within the programme, although it could be more proactive. For instance, the Board did note that the compliance with completing the assessment forms could be better, and that the programme would benefit from separate forms for assessment of the bachelor's and master's project, but did not closely monitor the follow-up of these recommendations. The panel recommends that the Board take a more proactive and normative stance towards the programme management.

The panel noted that the assessment within the society-oriented specialisations is fully mandated to the related Boards of Examiners. In order to improve the coherence between these specialisations and the physics-oriented side of the programme (discussed under Standard 2), the panel recommends that the programme investigate whether there could be more involvement in the assessment of the society-oriented specialisations. The programme could, for instance, consider providing second examiners for the projects within the specialisations to monitor more closely the performance of their students within these specialisations.

Considerations

The master's programme Physics has an adequate assessment system that assesses students on all intended learning outcomes. The assessment methods are varied and fit the programme's goals. A quality assurance system with a peer-review principle applied to all exam questions and the assessment of the master's project enhances the validity and transparency of student assessment. The panel advises better monitoring of the compliance with completing the assessment forms and the designing of separate rubrics for the bachelor's and master's projects. The Board of Examiners adequately fulfils its role in the quality assurance of assessment, but could take a more proactive and normative stance towards the programme management. The panel recommends investigating options for more involvement in the assessment of the society-oriented specialisations, for instance by providing second examiners for projects.

Conclusion
Master's programme Physics: the panel assesses Standard 3 as 'meets the standard'.

Standard 4: Achieved learning outcomes
The programme demonstrates that the intended learning outcomes are achieved.

Findings

Final projects
Students conclude the programme with either one or two research projects, depending on their track. During these projects, students are embedded within one of LION's research groups. Before the site visit, the panel studied the work of 9 students, which due to the double thesis philosophy consisted of 13 theses (see Working Method), divided over the five specialisations. This selection also included three physics projects by students who chose a society-oriented specialisation. The panel was very positive about the quality of the master's theses. The individual embedding of students in a research group and their training by active researchers were clearly reflected in the high quality of the works, which showed good academic and research skills. Students who conducted two research projects were able to demonstrate their research skills in two different settings, which was highly valued by the panel. The final projects by students who chose a society-oriented specialisation were deemed adequate by the panel to cover the intended learning outcomes of the programme.

Performance of alumni
A recent survey conducted by the programme revealed that all alumni find a job, most of them within a few months. A high number of the programme's alumni (62%) start a PhD in the Netherlands (42%) or abroad (20%). The remaining 38% start their career outside academia in either research and development, finance and consulting, IT & Data Science or education. The survey also showed that 28% of the programme's alumni is still in academia five to ten years after graduation, while the rest is employed outside the university, most prominently in R&D, finance and consulting, or IT & Data Science.

According to the panel, the high number of alumni continuing in research and academia reflect the successful realisation by students of the programme's goals and intended learning outcomes, which are focused on research and academic skills. It congratulates the programme on its success in this aspect, as well as on the excellent job perspectives of its alumni.

Considerations
The panel concludes that the final projects of the master's programme Physics are of a good quality, and convincingly show that the intended learning outcomes of the programme are achieved by the students. The individual embedding of students in a research group and their training by active researchers was clearly reflected in the high quality of the works, which showed good academic and

research skills. This is further demonstrated by the high number of alumni who start a PhD and the excellent job perspectives of all alumni.

Conclusion

Master's programme Physics: the panel assesses Standard 4 as 'meets the standard'.

GENERAL CONCLUSION

The panel assesses all standards of the NVAO's Framework for limited programme assessments 2018 for the master's programme Physics as 'meets the standard'. According to the decision rules of the framework, the panel assesses the master's programme Physics as positive.

Conclusion

The panel assesses the *master's programme Physics* as 'positive.

APPENDICES

APPENDIX 1: DOMAIN-SPECIFIC FRAMEWORK OF REFERENCE

Introduction
The goal of a university programme is to prepare students for an independent practice of the profession of the relevant discipline, and to give them the ability to apply the knowledge and skills they have acquired. Dutch university programmes in the domain of (applied) physics and astronomy are required to reach a level which allows the graduate to be competitive in the international research or in the job market, in particular with respect to countries which have a high profile in these areas. The domain specific reference frame is meant to be a gauge for reaching this goal.

The framework is based on that used in the Teaching Programme Assessment (Onderwijsvisitatie) of 2013. This in its turn was derived from the qualifications as formulated in the document 'Reference points for the design and delivery of degree programmes in physics', which was a product of the so-called Tuning Project63[1] and, to a lesser extent, the document 'A European Specification for Physics Master Studies' of the European Physical Society (2009). The 2013 framework has been modified and updated in three ways: (1) the programme descriptors are now divided over the usual five Dublin indicators, instead of over the original three categories: cognitive competences, practical skills, and generic competences, (2) several competences have been rephrased, (3) the competence 'Estimation skills' has been added.

The descriptors for the programmes have been formulated in terms of competences acquired by the graduating student, which leads to specific requirements for the curriculum. Programmes with the same name at different (Dutch) universities will in general not be identical. Different specialisations in the research staff or focus on particular subjects leads to differences in the eligible part of the programmes, and there is a structural difference between (the goals of) general universities and universities of technology. As a consequence, there are different ways to comply with the requirements of the reference frame. Essential is that the local choices for, and focus of the programme fit the internationally accepted standards.

Programme descriptors
The descriptors for the Bachelor's degree programmes in Physics, Applied Physics, and Astronomy are divided over the five Dublin descriptors, where the highest or most relevant descriptor is used for this division. The number in the second column is the 'Rating of importance' at the Bachelor level mentioned in the Tuning Physics document. The competence 'Estimation skills' and the related competence 'Problem solving skills' are combined (ratings 2 and 9). The three colors indicate the type of competence: light color = core curriculum, medium color = familiarity with physics research, dark color = general skills.

[1] In May 2018 a new version of the Tuning document was published, as output of the CALOHEE project (https://www.calohee.eu/). In this document, a different structure of competences is proposed (nine 'disciplines', each divided into 'knowledge', 'skills' and 'wider competences'). The compilers of the present framework have decided to follow the simpler, yet elegant structure of the Tuning 2008 document. Where relevant, aspects of the Tuning (2018) have been incorporated.

(A) Knowledge and understanding

	Rating of importance	Specific competence	Description. On completion of the degree course, the student should
A1	5	Knowledge and understanding of physics	have a good understanding of the important physical theories (logical and mathematical structure, experimental support, physical phenomena described).
A2	14	Understanding of the physics culture	be familiar with the most important areas of physics and with the common approaches, which span many areas in physics.
A3	8	Frontier research (MSc only)	have a good knowledge of the state of the art in (at least) one of the presently active topics in physics research.

(B) Applying knowledge and understanding

		Specific competence	Description. On completion of the degree course, the student should
B1	2, 9	Problem solving skills, Estimation skills	be able to frame, analyse and break down a problem in phases defining a suitable algorithmic procedure; be able to evaluate clearly the orders of magnitude in situations which are physically different, but show analogies, thus allowing the use of known solutions in new problems.

B2	1	Modelling skills	be able to identify the essentials of a process/situation and to set up a working model of the same; be able to perform the required approximations; *i.e.* critically think about how to construct physical models.
B3	7	Mathematical skills	be able to understand and master the use of the most commonly used mathematical and numerical methods.
B4	10	Experimental skills	have become familiar with most important experimental methods and be able to perform experiments independently, as well as to describe, analyse and critically evaluate experimental data; and to be able to scientifically report the findings.
B5		Computer skills	be able to use appropriate software, programming language, computational tools and methods in physical and mathematical investigations.
B6	6	Familiarity with basic and applied research	acquire an understanding of the nature and ways of physics research and of how physics research is applicable to many fields other than physics, *e.g.* engineering; be able to design experimental and/or theoretical procedures for: (i) solving current problems in academic or industrial research; (ii) improving the existing results.

(C) Judgement

C1	13	Human / professional skills	be able to develop a personal sense of responsibility; be able to gain professional flexibility through the wide spectrum of scientific techniques offered in the curriculum; be able to organize the personal learning process, evaluate personal work, consult experts for information (*e.g.* about career opportunities) and support when

			appropriate; have had the opportunity to take courses that prepare for teaching physics at secondary school, as well as the opportunity to gain in-depth interdisciplinary skills.
C2	18	Absolute standards	have become familiar with highly regarded research in the field, thus developing an awareness of the highest standards.
C3	17	Ethical awareness (relevant for physics)	be able to understand the socially related problems related to the profession, and to comprehend the ethical characteristics of research and of the professional activity in physics and its responsibility to society; be able to conduct processes of decision making and inspect the consequences of actions taking into account principles, norms, values and standards both from a personal and a professional standpoint.
C4	12	Management skills (MSc only)	be able to work with a high degree of autonomy, even accepting responsibility in (project) planning, and in the managing of structures.

(D) Communication

D1	11	Communication skills	be able to listen carefully and to present difficult ideas and complex information in a clear and concise manner to a professional as well as to lay audiences; be able to work in a multidisciplinary or in an interdisciplinary team.
D2	16	Language skills	be able to read, speak, and write in technical English.

(E) Learning

E1	3	Literature search	be able to search for and use physical and other technical literature, as well as any other sources of information relevant to research work and technical project development.
E2	4	Learning ability	be able to enter new fields through independent study; have developed those learning skills that are necessary for them to continue to undertake further study with a high degree of autonomy (lifelong learning).
E3	15	Updating skills (MSc only)	enjoy the facility to remain informed of new developments and methods, and be able to provide professional advice on their possible impact or range of applications.

APPENDIX 2: INTENDED LEARNING OUTCOMES

Final qualifications of Faculty of Science	Final qualifications used by the programme (derived from the DSRF) *(dots indicated shortenings)*
A. Knowledge and understanding	
A graduate has: * the ability to interrelate and integrate various areas of the discipline;	On completion of the degree course, the student should: A1. Have a good understanding of important physical theories … A2. Be familiar with the most important areas of physics and with the common approaches, which span areas in physics. A3. Have a good knowledge of state of the art in one of the presently active topics in physics research.
B. Applying knowledge and understanding	
* theoretical and/or practical skills in more than one specialist area of the discipline such that they can carry out research under overall supervision; * the ability to make an independent analysis of scientific problems, analysis of relevant specialist literature, formulate verifiable hypotheses, and set up and carry out research and critical reflection on one's own research and that of others;	B1. Be able to frame, analyze and break down a problem in phases… B2. Be able to identify the essentials of a process/situation … construct physical models. B3. Be able to master the use of the most commonly used mathematical and numerical methods. B4. … Be able to perform experiments independently, …, critically evaluate experimental data, … scientifically report the findings. B5. Be able to use appropriate software, programming language, computational tools … B6. Acquire an understanding of the nature and ways of physics research … solving problems in academic or industrial research
C. Judgement	
* sufficient understanding of the social role of the natural sciences to be able to reflect upon them and in part consequently to come to an ethically sound attitude and corresponding execution of one's professional duties;	C1. Be able to develop a personal sense of responsibility, … organize the personal learning process, … consult experts for information … C2. Have … developed an awareness for the highest standards (in research in the field) C3. Be objective, unbiased and truthful in all aspects of their work and recognize the limits of their knowledge … C4. Be able to work with a high degree of autonomy, even accepting responsibility in planning and management.
D. Communication	
* the ability to present clearly, verbally as well as in writing, one's own research results, and the ability to communicate with colleagues and to present their research results as a contribution to a congress or as (part of) a scientific publication;	D1. Be able to listen carefully and to present difficult ideas and complex information in a clear and concise way to a professional as well as to lay audiences; be able to work in a multidisciplinary or in an interdisciplinary team. D2. Be able to read, speak and write in technical English
E. Learning (Skills)	
* the learning skills to allow them to continue to study in a manner that may be largely self-directed or autonomous.	E1. Be able to search for and use physical and other technical literature … E2. Be able to enter new fields through independent study… E3. … Be able to provide professional advice on the possible impact or range of … new developments and methods.

For the master specialisations Business Studies, Science Communication and Society and Education, the following additional achievement levels apply:

Business Studies specialisation:

a. insight in managerial issues related to knowledge-intensive businesses and basic theoretical skills in business disciplines most relevant to working in these businesses;
b. the ability to make a plan for a new business or an innovation project;
c. experience with performing business activities in an existing company or organisation or directed towards technology-based business creation.

Science Communication and Society specialisation:

a. knowledge of and skills in science communication theory and methods ;
b. experience in science communication practice;
c. knowledge of ethical, historical and social aspects in the area of the natural sciences.

Education specialisation:

- all qualifications necessary for teaching all years of secondary education and technical and vocational training (students from 12 to 18 years old).

APPENDIX 3: OVERVIEW OF THE CURRICULUM

Specialization	Year 1			Year 2		
Theory	Core (15 EC)	Extended core (15EC)	Electives (42 EC)	Research project (48 EC)		
BSM / QMO		Electives (45 EC)		Research project 1 (24 EC)	Research project 2 (36 EC)	
Cosmology		Extended core (18 EC)	Electives (27 EC)	Research project 1 (30 EC)	Research project 2 (30 EC)	
Casimir pre-PhD		Electives (45 EC)		Research project (36 EC)	Study projects (2 x 8 EC)	Research proposal (8 EC)
Physics + SBB		Elective (9 EC)	Research project (36 EC)	SBB courses (20 EC)	SBB internship (20-40 EC)	Electives SBB or physics (0-20EC)
Physics + SCS		Elective (9 EC)	Research project (36 EC)	SCS courses (23 EC)	SCS project (17-37 EC)	Electives SCS or physics (0-20 EC)
Physics + EDU		Elective (9 EC)	Research project (36 EC)	EDU courses (30 EC)	Teaching practice 1 (15EC)	Teaching practice 2 (15EC)

Physics

First semester

Vak	EC
Advanced Optics	6
Advanced Topics in Theoretical Physics I: Topological Methods in Theoretical Physics	6
Biophysics	6
Complex networks (BM)	6
Condensed Matter Physics	6
Effective Field Theory	3
Frontiers of Measurement Techniques	3
Origin and Structure of the Standard Model	3
Quantum Information	3
Quantum Theory	6
Soft and Biomatter Theory	6
Statistical Physics a	6
Statistical Physics b	3
Theory of General Relativity	6

Second semester

Vak	EC
Academic and Professional Skills (Science)	3
Advanced Topics in Theoretical Physics II: Hydrodynamics and collective dynamics	6
Computational Physics (3 EC)	3
Computational Physics (6 EC)	6
Mechanical Metamaterials	6
Molecular Electronics	6
Particle Physics and Early Universe	3
Quantum Field Theory	6
Quantum Optics	6
Superconductivity	3
Surface Science (SUS)	6
Technological Biophysics	3
Theory of Condensed Matter	6
Theoretical Biophysics	6
Theoretical Cosmology	3
Topics in Theoretical Physics: Physics of Machine Learning	6

Research in Physics: Theoretical Physics

Vak	EC
Mandatory Courses 30 EC	
Academic and Professional Skills (Science)	3
Effective Field Theory	3
Quantum Information	3
Quantum Theory	6
Statistical Physics a	6
Statistical Physics b	3
Topics in Theoretical Physics: Physics of Machine Learning	6
Electives 42 EC - select from MSc Physics courses of which ≥ 12 EC from Theoretical Physics courses	
Advanced Topics in Theoretical Physics I: Topological Methods in Theoretical Physics	6
Advanced Topics in Theoretical Physics II: Hydrodynamics and collective dynamics	6
Black Holes and Gravitational Waves	3
Complex networks (BM)	6
Computational Physics (3 EC)	3
Computational Physics (6 EC)	6
Origin and Structure of the Standard Model	3
Particle Physics and Early Universe	3
Quantum Field Theory	6
Soft and Biomatter Theory	6
Theoretical Biophysics	6
Theoretical Cosmology	3
Theory of Condensed Matter	6
Theory of General Relativity	6
Research Project 48 EC - Research =36 EC - Thesis =8 EC - Presentation= 4 EC	

Research in Physics: Biological and Soft Matter Physics

Vak	EC
Mandatory Courses 15 EC	
Academic and Professional Skills (Science)	3
Quantum Theory	6
Statistical Physics a	6
Electives 45 EC - select from MSc Physics courses of which ≥ 12 EC from Biological and Soft Matter c	
Biophysics	6
Advanced Optics	6
Computational Physics (3 EC)	3
Computational Physics (6 EC)	6
Evolution and Engineering of Living Systems (Delft)	6
Frontiers of Measurement Techniques	3
Imaging Systems (Delft)	6
Mechanical Metamaterials	6
Molecular Electronics	6
Soft and Biomatter Theory	6
Statistical Physics b	3
Technological Biophysics	3
Theoretical Biophysics	6
The Origins of Life (Delft)	6
Research Project 1 (24 EC) Research=20 EC Thesis=3 EC Presentation=1 EC Research Project 2 (36 EC) Research= 30 EC Thesis = 4 EC Presentation= 2 EC	

Research in Physics: Quantum Matter and Optics

Vak	EC
Mandatory Courses 15 EC	
Academic and Professional Skills (Science)	3
Quantum Theory	6
Statistical Physics a	6
Electives 45 EC - select from MSc Physics courses of which ≥ 12 EC from Quantum Matter and Optics	
Advanced Optics	6
Computational Physics (3 EC)	3
Computational Physics (6 EC)	6
Condensed Matter Physics	6
Frontiers of Measurement Techniques	3
Molecular Electronics	6
Quantum Information	3
Quantum Optics	6
Superconductivity	3
Surface Science (SUS)	6
Theory of Condensed Matter	6
Research Project 1 (24 EC) Research= 20 EC Thesis= 3 EC Presentation = 1 EC Research Project 2 (36 EC) Research = 30 EC Thesis = 4 EC Presentation = 2 EC	

Research in Physics: Cosmology

Vak	EC	Semester 1	Semester 2
Origin and Structure of the Standard Model	3		
Origin and Evolution of the Universe	6		
Quantum Theory	6		
Theory of General Relativity	6		
Academic and Professional Skills (Science)	3		
Large Scale Structure and Galaxy Formation	6		
Particle Physics and Early Universe	3		
Electives 27 EC - select from MSc Physics courses or MSc Astronomy of which ≥ 12 EC from the Cosmology courses below			
Effective Field Theory	3		
Computational Astrophysics	6		
Modern Astrostatistics	3		
Theoretical Cosmology	3		
Other electives for Cosmology Please visit the **Astronomy and Cosmology webpage** to select other electives			
Research Project Cosmology 1			
Research Project Cosmology 2			

Research in Physics: Casimir pre-PhD

Vak	EC
Mandatory Courses 15 EC	
Academic and Professional Skills (Science)	3
Quantum Theory	6
Statistical Physics a	6
Electives 45 EC: 1.Select form Casimir pre-PhD courses in Delft and/or 2.Select from MSc Physics courses -see specialisations	
1.Electives form Casimir pre-PhD courses in Delft Foundation courses Advanced Electrodynamics Advanced Solid State Physics Continuum Physics Topic related courses Evolution and Engineering of living systems Fundamentals of Quantum Information Mesoscopic Physics Molecular Electronics Quantum Communication and Cryptography Quantum Hardware Quantum Optics and Lasers The origins in Life Topology in Condensed Matter Methods Computational Physics (3 EC) Computational Physics (6 EC) Electronics for Quantum Computing Molecular Electronics Nanotechnology	
2.Electives from MSc Physics Courses Master specialisation Biological and Soft Matter Physics Master specialisation Cosmology Master specialisation Quantum Matter and Optics Master specialisation Theoretical Physics	
Research project Physics 36 EC Research = 30 EC Thesis = 4 EC Presentation =2 EC	
Study Projects 16 EC Study Projects > 2 x 8 EC projects	
Writing Proposal 8 EC	

Physics: Business Studies

Vak	EC
1.Physics programme 60 EC:	
> Mandatory Courses 15 EC	
Academic and Professional Skills (Science)	3
Quantum Theory	6
Statistical Physics a	6
> Research Project 36 EC Research =30 EC Thesis =4 EC Presentation =2 EC	
> Electives 9 EC (select from corresponding master specialisation) Master specialisation Biological and Soft Matter Physics Master specialisation Cosmology Master specialisation Quantum Matter and Optics	
2.Business Studies programme 60 EC: selection from two different tracks	
Management Track Management Track	
New Technology Ventures Track New Technology Ventures Track	

Physics: Science Communication and Society

Vak	EC
Physics programme (60 EC):	
> Mandatory Courses 15 EC	
Academic and Professional Skills (Science)	3
Quantum Theory	6
Statistical Physics a	6
> Research Project 36 EC Research =30 EC Thesis =4 EC Presentation =2 EC	
> Electives 9 EC (select courses in correspondence with the research project)	
Science Communication and Society (SCS) Programme (60 EC): Science Communication and Society	

Physics: Physics and Education

The Physics and Education specialisation prepares students for a career in physics teaching and results in the teacher qualification (eerstegraads lesbevoegdheid) required for employment as a teacher in Dutch secondary schools. It is a joint programme offered in collaboration with the Leiden University Graduate School of Teaching (ICLON). The programme consists of a Physics component (60 EC), to be followed during the first year, and an Education component (60 EC; only taught in Dutch), to be followed in the second year.

Physics Programme (60 EC):

Mandatory Courses (15 EC)

Electives (9 EC)

Research Project (36 EC)

Education Programme (60 EC):

	Level	EC
Educational Theory	400	5
Learning and Instruction 1	300	5
Learning and Instruction 2	400	3
Teaching Methodology 1	400	5
Teaching Methodology 2	500	5
Design Research	600	7
Teaching Practice 1		15
Teaching Practice 2		15

For students who passed the minor Education (30 EC) during the BSc programme, the programme consists of the following:

	Level	EC
Learning and Instruction 2	400	3
Teaching Methodology 2	500	5
Design Research	600	7
Teaching Practice 2		15

APPENDIX 4: PROGRAMME OF THE SITE VISIT

Tuesday 23 April
09.00 – 09.15 Arrival
09.15 – 11.00 Internal panel session
11.00 – 12.00 **Interview programme management**
12.00 – 12.30 Consultation hour
12.30 – 13.30 Lunch
13.30 – 14.15 **Tour of the facilities**
14.15 – 14.30 Break
14.30 – 15.30 **Interview Students bachelor Physics + Astronomy**
15.30 – 15.45 Break
15.45 – 16.30 **Interview students master Astronomy**
16.30 – 17.15 **Interview students master Physics**
17.15 – 17.45 Internal panel session

Wednesday 24 April
09.00 – 09.30 Internal panel session
09.30 – 10.15 **Interview teaching staff Astronomy (bachelor + master)**
10.15 – 11.00 **Interview teaching staff Physics (bachelor + master)**
11.00 – 11.30 Break
11.30 – 12.15 **Interview Board of Examiners**
12.15 – 13.15 Lunch
13.15 – 14.00 **Interview programme management**
14.00 – 16.00 Internal panel session
16.00 – 16.15 **Oral report**
16.15 – 17.00 **Development dialogue**
17.15 – 17.30 Wrap up

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

Prior to the site visit, the panel studied 13 theses of the master's programme Physics. Information on the selected theses is available from QANU upon request.

During the site visit, the panel studied, among other things, the following documents (partly as hard copies, partly via the institute's electronic learning environment):

- Intended learning outcomes
- Curriculum overview
- Overview programme content (study guide, electronic learning environment and a selection of course materials)
- Selection of exam questions and answer models
- Education and Exam Regulation
- Teaching staff overview
- List of theses
- Annual reports Board of Examiners Physics
- Annual reports Programme Committee master Physics
- Minutes Programme Committee master Physics