MASTER’S PROGRAMME PHYSICS

FACULTY OF SCIENCE

UTRECHT UNIVERSITY

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This report was finalized on 4 October 2019

REPORT ON THE MASTER'S PROGRAMME MASTER'S PROGRAMME PHYSICS OF UTRECHT 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:	Natuurkunde en Meteorologie & Fysische Oceanografie
CROHO number:	60705
Level of the programme:	master's
Orientation of the programme:	academic
Number of credits:	120 EC
Specializations or tracks:	Theoretical Physics Experimental Physics Climate Physics
Location:	Utrecht
Mode of study:	full time
Language of instruction:	English
Submission deadline NVAO:	01/11/2019

Note: The name of the programme was 'Natuurkunde en Meteorologie & Fysische Oceanografie'. The programme's management has applied for a name change to 'Physics' with the Accreditation Organisation of the Netherlands and Flanders (NVAO), which has been approved. In CROHO the programme is still registered as 'Natuurkunde en Meteorologie & Fysische Oceanografie' The programme will use the new name of 'Physics' in all documentation from year 2019/2020. For the purpose of this English report, the new name of 'Physics' will be used.

The visit of the assessment panel Physics and Astronomy to the Faculty of Science of Utrecht University took place on 4 and 5 June 2019.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

Name of the institution:	Utrecht 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 14 January 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, in 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;
- Prof. 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. G. (Geert) Vanpaemel, professor for History of Science and Science Communication at KU Leuven, Belgium;
- B. N. R. (Bram) Lap BSc, master's student Astronomy at University of Groningen [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 Utrecht 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, in 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;
- Prof. 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. 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, who 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 15 theses and their assessment forms for the programme, based on a provided list of graduates between 2017-2018. 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 Utrecht University took place on 4 and 5 June 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 another project manager for peer assessment. Subsequently, the secretary sent the report to the panel. After processing the panel members' feedback, the secretary sent the draft reports to the faculty in order to have these checked for factual irregularities. The secretary 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 research-oriented programme in Physics with many opportunities to specialize in the direction of theoretical physics, experimental physics and climate physics. The panel is especially positive about the unique climate physics specialization. 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. Each specialization has made a coherent translation of the intended learning outcomes into content-specific learning outcomes for the specialization. The panel recommends addressing the inconsistency in communication skills between the three sets of learning outcomes.

The teaching-learning environment of the programme facilitates students achieving the intended learning outcomes of the programme. The specializations offer them the opportunity to deepen their knowledge and skills in physics, and provide them with a large amount of flexibility and choice to compose their own curriculum. The programme provides students with guidance and coaching throughout their curriculum, assisting them to compose a feasible and coherent programme. The panel recommends that the THPH and EXPH specializations embed skills training better in their mandatory courses to ensure the same level of skills training for each student. It also thinks that there are opportunities for programme-wide courses (or at least between THPH and EXPH), which can be used to further develop skills in interdisciplinary teamwork and communication. It recommends that the programme reconsider the prerequisites for entering the specializations, as this limits a seamless connection between the bachelor's and master's programme at Utrecht University and requires students to sacrifice 15 EC of electives in either their bachelor's or master's programme for non-optional courses.

The teaching staff is capable and approachable for students. The programme invests in the professionalization of the teaching staff, which is particularly visible in the high percentage of STQ-certified staff members. It facilitates innovative teaching methods and provides adequate facilities to its students. The feasibility of the programme is adequate and has improved notably in the past years, in particular due to the streamlining of the master's theses timeline. The panel fully supports the use of English in this master's programme and believes that this is the obvious choice in light of the programme's goals.

The master's programme Physics has an adequate assessment system that assesses students on all intended learning outcomes. Its quality assurance system with a peer-review principle applied to all exam questions and the assessment of the master's project, and frequent sampling to determine the quality of exams and the final project enhance the validity and transparency of student assessment. The form could be improved by including the grades of the two examiners separately, and by refining the labels used in the rubric. For the THPH and EXPH specializations, the panel recommends accompanying the strengthening of the academic skills training with the associated assessment forms such as reports, essays and presentations. It recommends including software for automated plagiarism detection for the master's projects.

The Board of Examiners adequately fulfils its role in the quality assurance of assessment. The panel thinks that this fits the educational philosophy of the university, with students often following courses in other programmes. A more centralised system of assessment and a central Board of Examiners allows for more coherence in assessment between the individual programmes.

The panel concludes that the final projects of the master's programme Physics are of good quality and convincingly show that the intended learning outcomes of the programme are achieved by the students. This is further demonstrated by the high number of graduates who start a PhD and the good job perspectives of all students.

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, prof. dr Reinder Coehoorn, and the secretary, Peter Hildering MSc, of the panel 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: 4 October 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

Mission and vision
The master's programme Physics & Meteorology and Physical Oceanography of Utrecht University is part of the Faculty of Science. In 2018, the programme successfully applied for a name change to "Physics", which will be implemented in 2021. In the remainder of this report, this name will already be used for reasons of convenience. The master's programme Physics is part of the Graduate School of Natural Sciences (GSNS) together with all the other master's programmes at the faculty. The GSNS organizes the quality control of the programme. Therefore, the Educational Council and the Board of Examiners are organized at the level of the Graduate School. In its educational programmes, Utrecht University values freedom of choice by students and provides them with the opportunity to adapt their curriculum to their personal goals. The centralized system of quality assurance is aimed at facilitating students to attend educational components at other degree programmes.

The degree programme Physics aims to prepare its students for conducting research in both a disciplinary and an interdisciplinary environment, using their knowledge and skills to solving problems in the natural sciences. To this end, they are provided with the knowledge and understanding of physical phenomena, processes and their mathematical modelling, while also being trained in the skills and attitudes that are necessary for being a researcher. Within this overarching goal, the programme consists of three separate specializations. At the start of the programme, students choose one of them and follow the associated curriculum.

- Theoretical Physics (THPH) is organized by the Institute for Theoretical Physics and is focused on the two research lines of the institute: String Theory, Cosmology, Elementary Particles (fundamental physics theories at very high energies) and Condensed Matter Theory, Statistical and Computational Physics (understanding macroscopic phenomena on the basis of microscopic many-body theories)
- Experimental Physics (EXPH) is centred around three key themes: Particle Physics (organized by the Institute of Subatomic Physics), Nanophotonics, and Soft Condensed Matter and Biophysics (both tied to the Debye Institute of Nanomaterials)
- Climate Physics (CLPH) focuses on the physical and chemical processes that make up the Earth's climate system. It is offered by the Institute for Marine and Atmospheric research Utrecht (IMAU) and is subdivided into five research themes: Ice and Climate, Atmospheric Dynamics, Oceans and Climate, Coastal and Shelf Sea Dynamics, and Atmospheric Physics and Chemistry

The panel is positive about the programme's clear profile centred around educating researchers. The three specializations and the themes within these specializations offer students a wide range of options to choose from. The panel is particularly positive about the choice to offer the CLPH specialization, the only one of its kind in the Netherlands and one of the most complete programmes on this topic in Europe. It considers climate physics a very relevant field in light of current societal challenges and is pleased with the opportunity the programme offers students to specialize in this direction.

The panel noted that the three specializations are organized in separate curricula with little overlap. Given the programme's goal to prepare students to conduct research in an interdisciplinary environment, it thinks that they could profit from more cross-fertilization between the specializations.

This is especially the case for THPH and EXPH, which are embedded in more disciplinary research institutes compared to CLPH. The panel recommends that the programme investigate possibilities to create more shared educational components between THPH and EXPH in order to create a more interdisciplinary environment for its students.

Intended learning outcomes
The programme has derived its intended learning outcomes (Appendix 2) from the domain-specific reference framework for Physics (Appendix 1). 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 effort at the European level (Tuning Physics) to internationally align the Physics and Astronomy programmes. These intended learning outcomes use the Dublin descriptors to describe the knowledge, insights and skills that each master's student in Physics should obtain, regardless of his or her specialization. In addition, each specialization has made a translation of the programme's intended learning outcomes into learning outcomes specific for that specialization. The learning outcomes are evaluated each year by the programme management under the auspices of the GSNS to check whether they are still accurate and up-to-date.

The panel studied the programme's intended learning outcomes, including the ones that are specific to the three specializations. It deems the 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 in the domain-specific reference framework and through the inclusion of skills such as frontier research, critical thinking and ethical awareness. The panel is positive about the alignment of the Physics and Astronomy programmes at a European level and thinks that this enhances the wide recognition of the knowledge, insights and skills acquired by the students by both the academic and the professional field.

The translations at the level of the specializations are mostly equivalent to the programme's learning outcomes and show what content-specific knowledge and skills the graduates are expected to achieve. The panel spotted one notable difference between the specializations: EXPH and CLPH lists the specific communication skills 'multidisciplinary and international teamwork' and 'communication with non-specialists' whereas THPH doesn't. It recommends harmonizing the learning outcomes in this aspect, as these skills are important for all specializations.

Considerations
The master's programme Physics convincingly profiles itself as a research-oriented programme in Physics with many opportunities to specialize in the direction of theoretical physics, experimental physics and climate physics. The panel is especially positive about the unique climate physics specialization. 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. Each specialization has made a coherent translation of the intended learning outcomes into content-specific learning outcomes for the specialization. The panel recommends addressing the inconsistency in communication skills between the three sets of learning outcomes.

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 three specializations of the master's programme Physics each have their own curriculum, which is structured in a similar way. The first year is spent on mandatory theoretical courses (22-38.5 EC), primary electives (21.5-30 EC) and secondary electives (15 EC). For THPH and CLPH, some of the courses are taken in the second year. There are also two small shared courses between the specializations: Introduction to Natural Sciences and the scientific integrity course, Dilemmas of the Scientist (0.5 EC each). The mandatory courses cover the core aspects of the specific research field as well as the necessary skills. The primary electives are meant to give students the opportunity to select a study path in a specific discipline with regard to their final research project. The secondary electives allow them to gain knowledge and skills outside the framework of the master's programme. In the second year of their curriculum, the students undertake their master's research project (44-60 EC), in which they investigate a new problem within the specialization. They can choose their own topic but are supposed to conduct their research under the close supervision of a supervisor, who provides guidance and feedback. The programme facilitates a number of alternatives to the programme structure. Students can opt for a 30 EC internship (only EXPH) or for a more structured 30 EC profile in Education, Complex Systems or Applied Data Science, which replaces their secondary electives and 15 EC of their research project. They can also opt for a TWIN programme, in which they combine two master's programmes in a three-year curriculum. These curricula are created on an individual basis upon request, pending permission of the programme directors and the Board of Examiners.

Students are free to choose their preferred programme structure. The courses have little interdependence, and ones with prerequisites are scheduled more than once per academic year. There are frequent consults between the students and the programme coordinator, in which they discuss the student's progress and preferred study path. Students also often consult their prospective thesis supervisor for advice to determine a set of coherent electives that tie in to the topic of their preferred master's research project. All three specializations have core courses focused on developing research skills (such as the student seminar in THPH, the Nikhef project in EXPH, and Simulation of Atmosphere, Ocean and Climate in CLPH), which are trained in the final research project under the supervision of an active researcher. In response to recommendations from the previous accreditation panel, the programme has invested in career orientation. The programme and the study association organize a career day during which companies present themselves, and the faculty has appointed a career officer who helps students orient themselves towards their future career.

The panel studied the curriculum of the programme and the content of the specializations and believes that they offer students ample opportunity to develop themselves as a researcher in physics. It values the amount of flexibility and choice offered to the students to compose their own curriculum and deviate from the standard curriculum if they wish. The fact that students are individually supervised by an experienced researcher over the course of their master's project offers them hands-on experience in research, fitting to the goals of the programme. The panel thinks the extra effort in career orientation is positive. It also wants to point out that a programme with a research orientation such as this one runs a risk of focusing so much on a career path in research that it loses track of students who do not want to continue their career in this direction. It recommends keeping an eye on this and offering sufficient options for students who want employment in industry. The programme could, for instance, consider inviting guest lecturers from companies. Concerning the skills education in the THPH and EXPH specializations, the panel notes that this is often addressed in electives. The students confirmed to the panel that this means that not all students have the same level of training in certain academic skills, depending on their choice of electives. The panel recommends that these two specializations embed skills training better in the mandatory courses to ensure the same level of skills training for each student. In its opinion, the programme might consider using programme-wide courses (discussed under Standard 1) to teach the interdisciplinary teamwork and communication skills, to provide the students with the opportunity of working in groups of students.

The panel noted that the prerequisites for entering the master's programme include having taken specific bachelor's courses within the field of the specialization. If students have not taken these courses in their bachelor's programme, they are required to spend their 15 EC of secondary electives on these courses. The panel recommends that the programme reconsider these entry requirements, as it hinders a seamless connection between the bachelor's and master's programme at Utrecht University and requires students to sacrifice 15 EC of otherwise free electives in either their bachelor's or master's programme for non-optional courses.

Teaching staff
Most of the teaching staff of the programme is affiliated with the Physics department as researchers. They align their teaching with their research expertise. The scientific staff of the department is 43.9 fte (per 2018), with each staff member being appointed with a teaching assignment of 40% of their time. Given a student population around 600 students (bachelor and master combined), this leads to a student-staff ratio of 33-35 students per fte. To assist the research staff with their high teaching load, the programme has introduced so-called super teaching assistants (super TAs). These are PhD students or postdocs who have a contract extension of three months, which they can use for teaching support. The focus of their work lies in assisting with tutorials and supporting educational innovations. The programme aims to have all teachers acquire the University Teaching Qualification (UTQ) and encourages them to gain the Senior Teaching Qualification (STQ). Currently, 89% of the staff holds an UTQ and 60% a STQ. Teachers who follow the STQ course evaluate a part of the programme's curriculum and make recommendations for improvement. STQ education therefore has a direct positive effect on the programme's quality assurance.

Didactics
Due to the relatively small student numbers in the specialized courses, the programme mostly relies on small-scale, interactive teaching, and individual guidance and supervision by an active researcher throughout the final research project. This provides students with state-of-the-art knowledge in the field and allows him or her to learn research skills in a master-apprentice relationship. Some teachers use innovative teaching methods such as blended learning. A specialized department within the faculty supports teachers who want to use innovative teaching methods, and super TAs (see above) can be requested to support the implementation of these methods. Teachers also indicate that they can follow a training course if they feel they need it, and share best practices concerning teaching methods. The panel is positive about the didactics of the programme. It deems the interactive teaching and the individual supervision by active researchers fitting to the programme's goals of educating researchers. It is also positive about the use and support of innovative teaching methods by the programme and encourages it to continue this development.

The panel is very positive about the teaching staff of the programme. They are active researchers and qualified teachers, and as a result act as role models for the students. The students the panel interviewed praised the didactic quality, openness and availability of their teachers. They give swift replies, even if they experience a high workload, and the students feel welcome to discuss their questions and requests. The panel compliments the programme on the high level of professionalization of the teaching staff, which is expressed in the high percentage of UTQs. It also concludes that the super TAs are an adequate way of reducing the teaching load of the scientific staff without compromising the level of student guidance.

Feasibility
The master's programme Physics has an average study duration of 26 months (per 2017) and a low drop-out rate (5 out of 80 in 2017). Based on the recommendations of the previous accreditation panel, the programme has introduced measures to counter the delay caused by the final master project. The students have to start their project by filling out a Research Application Form detailing

their project and the associated timeline, which has to be approved by the supervisor. If the student does not complete the work by the agreed deadline, s/he receives a maximum of 6 (out of 10) on his or her work. This is meant to prevent students from taking extra time to get a better result and a higher grade. As a result, the average study duration has decreased from 29 months to 26 months since the introduction of these measures, which the programme considers a success. The students are satisfied with the feasibility of the programme and see no major obstacles within the curriculum. They appreciate the streamlining of the master's project timelines. To increase the feasibility of the programme for international students, each is assigned a student buddy from within the programme to help them get acquainted with studying in the Netherlands, which works well according to the students. The panel concludes that the curriculum is feasible and that the programme has taken adequate measures to improve the feasibility, in particular for the master's project.

Language and internationalization
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. Approximately 30 to 50% of the student population and one-third of the teaching staff is non-Dutch, which adds to the international character of the programme. As active researchers in the field, all of 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.

Programme-specific facilities
Once master students have reached the research project phase of their programme, they are considered to be junior researchers and have facilities similar to PhD students, such as a desk, a PC, access to the experimental set-ups and software of the research institute. They are also stimulated to be part of the research group as much as possible and attend symposia, colloquia and social events. The panel is positive about these facilities and thinks that this embedding in the research group, including the associated facilities, is a good way to learn to be a researcher.

Considerations

The teaching-learning environment of the programme facilitates students achieving the intended learning outcomes of the programme. The specializations offer them the opportunity to deepen their knowledge and skills in physics, and provide them with a large amount of flexibility and choice to compose their own curriculum. The programme provides students with guidance and coaching throughout their curriculum, assisting them to compose a feasible and coherent programme. The panel recommends that the THPH and EXPH specializations embed skills training better in their mandatory courses to ensure the same level of skills training for each student. It also thinks that there are opportunities for programme-wide courses (or at least between THPH and EXPH), which can be used to further develop skills in interdisciplinary teamwork and communication. It recommends that the programme reconsider the prerequisites for entering the specializations, as this limits a seamless connection between the bachelor's and master's programme at Utrecht University and requires students to sacrifice 15 EC of electives in either their bachelor's or master's programme for non-optional courses.

The teaching staff is capable and approachable for students. The programme invests in the professionalization of the teaching staff, which is particularly visible in the high percentage of STQ-certified staff members. It facilitates innovative teaching methods and provides adequate facilities to its students. The feasibility of the programme is adequate and has improved notably in the past years, in particular due to the streamlining of the master's theses timeline. The panel fully supports the use of English in this master's programme and believes that this is the obvious choice in light of the programme's goals.

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 uses an assessment plan which details how the intended learning outcomes are assessed within the courses. Each course has an assessment matrix which relates the course goals to the tests within the course. The assessment form varies depending on the specific course goals. This is often a written exam with open questions, but also includes programming assignments, presentations and essays. The quality of the exam questions and answers formulated by the course supervisor is checked beforehand by a second reader in terms of clarity, length, level and coverage of the course materials. Courses usually have multiple tests, providing students with a mid-term update on their performance. Checking for fraud and plagiarism is the responsibility of the individual supervisor; the Board of Examiners has tested several software packages for automated plagiarism detection but has not found one that meets its standards.

The quality of the courses is monitored by an Intervision Committee, consisting of teachers of the programme. This committee takes annual samples of courses and checks whether the assessment in these courses fits the course goals and is of sufficient quality. It also takes random samples of master's theses annually and studies the report and the assessment form to check whether the assessment has taken place according to the regulations. The committee provides its report to the programme director and the Executive Panel of Physics of the Board of Examiners, as well as to the entire teaching staff for discussion in the staff meetings. Through this process, each course is checked approximately once every four years.

The panel studied the assessment plan of the programme, an overview of the assessment methods and criteria per course, and some examples of exams used within the programme. It concludes that all intended learning outcomes are appropriately assessed throughout the programme. The second reader for all exams and the annual checks by the Intervision Committee add to the quality of assessment within the programme. The assessment methods in the CLPH mandatory core are varied and include multiple essays and presentations in addition to written exams, while the THPH and EXPH core mainly focuses on written exams. According to the panel, this is related to the integration of the academic skills learning line in the core of these two specializations (see Standard 2). It suggests the programme, when further integrating academic skills within the curriculum, to include the associated assessment forms such as reports, essays and presentations. It also recommends the use of automated plagiarism detection, and to introduce this for the master's project. It reckons the use of imperfect software to be better than no check at all.

Assessment of master's projects
To assess the final master's projects, the programme uses an assessment form that provides students with a detailed assessment of their project in terms of research, report and presentation, and includes feedback to improve their skills. The forms include rubrics that assist examiners to determine their grade. Each project is assessed by two examiners: the supervisor as the first examiner and a second reader from within the department as the second examiner. They each grade the various aspects of the project separately. After this, they fill out the assessment form together, with the final grade per aspect being the average of the two grades. Any large deviations between the two examiners should be noted in the comment box.

The panel is positive about the assessment of master's projects and the assessment forms. The students the panel interviewed were satisfied with the insightful grading and the extensive oral and written feedback they receive. The rubrics and the role of the second examiner add to the validity of the grading. The panel studied a number of assessment forms that were used in grading the master's projects it read prior to the site visit. It established that the forms are well designed and are filled out meticulously by the examiners. It thinks the programme has the opportunity to improve the transparency of the grading even more by mentioning the separate grades of the two examiners on the form rather than just their average. With respect to the rubrics, the panel noted that the qualitative labelling of the range of potential grades (for instance 'satisfactory' for 7-8) runs the associated risk of leading to misunderstanding when examiners have different conceptions relating to these labels. This is even more the case when the range of grades per label is variable. The panel recommends either giving a qualitative label to each grade or dropping these labels altogether and using grades only.

Board of Examiners
The GSNS has a faculty-wide Board of Examiners (EC-GSNS) that covers all master's degree programmes within the faculty. The EC-GSNS discusses the assessment policy and procedures for all programmes in general. Programme-specific tasks are delegated to the Executive Panels, which are assigned per domain. This includes course exemptions and approval of individual curricula within the programme. Students are in principle only in contact with the Executive Panel Physics and not with the EC-GSNS. THE EC-GSNS consists of the chairs of all Executive Panels and a dedicated chair. The Committee discusses exemptions to rules, student appeals against Executive Panel decisions, fraud and issues concerning individual examiners. Quality assurance of course assessment and the master's project is mandated to the Intervision Committee (discussed above). The university uses general, broad Boards of Examiners with domain-specific Executive Panels. This combines a highly qualified overarching central committee with an approachable local panel containing programme-specific knowledge.

The panel interviewed the Board of Examiners and studied a number of the Board's annual reports. In its opinion, the system with a central Board and domain-specific Executive Panels functions adequately, and the Board properly fulfils its role in the quality assurance of assessment within the programme. It thinks that the structure fits the educational philosophy of the university, with students often following courses in other programmes. A more centralised system of assessment and a central Board of Examiners allow for more coherence in assessment between the individual programmes.

Considerations
The master's programme Physics has an adequate assessment system that assesses students on all intended learning outcomes. Its quality assurance system with a peer-review principle applied to all exam questions and the assessment of the master's project, and frequent sampling to determine the quality of exams and the final project enhance the validity and transparency of student assessment. The form could be improved by including the grades of the two examiners separately, and by refining the labels used in the rubric. For the THPH and EXPH specializations, the panel recommends accompanying the strengthening of the academic skills training with the associated assessment forms such as reports, essays and presentations. It recommends including software for automated plagiarism detection for the master's projects.

The Board of Examiners adequately fulfils its role in the quality assurance of assessment. The panel thinks that this fits the educational philosophy of the university, with students often following courses in other programmes. A more centralised system of assessment and a central Board of Examiners allows for more coherence in assessment between the individual programmes.

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

Master's projects
Prior to the site visit, the panel studied 15 master's theses of the programme, spread over its three specializations. It established that all graduates have achieved the intended learning outcomes of the programme on a master's level. It considered the projects in general to be ambitious and of a high level for all three specializations. They confirmed adequate research skills, fitting the goal of the programme to educate researchers. The panel congratulates the programme on the level of its students.

Performance of graduates
An average of 50% of the programme's graduates continue their career in research as a PhD student. Others continue their career in applied research, industry, business or education. Graduates have in general no problem finding a job, which is confirmed by the alumni the panel interviewed. They are satisfied with the content and level of their education. Some would have preferred more attention to academic skills within the programme. The panel agrees with this, as discussed under Standard 2. It thinks the high number of students continuing in research reflects the high quality of the programme and the success regarding the programme's goals to educate researchers.

Considerations
The panel concludes that the final projects of the master's programme Physics are of good quality and convincingly show that the intended learning outcomes of the programme are achieved by the students. This is further demonstrated by the high number of graduates who start a PhD and the good job perspectives of all students.

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

GENERAL CONCLUSION

The panel judged that the master's programme Physics offered by Utrecht University meets all the standards of the NVAO assessment framework for limited programme assessment. The panel therefore advises positive about the accreditation of the programme.

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

Knowledge and understanding
The degree programme elaborates on theories and techniques that have been trained during a bachelor programme at an academic level with ample emphasis on physics. Therefore, one of the conditions to be admitted to the degree programme is a completed Bachelor of Science with a major in Physics, or a major in Science with strong components in Physics. Students that graduate in the master degree programme in Physics have a thorough knowledge and understanding of one of the core research themes in physics at Utrecht University.

Applying knowledge and understanding
The coupling between education and research is the core aspect of the degree programme. This means that students first learn about theories and methodologies, after which they apply them in scientific projects. These vary from reading and discussing international literature in groups to carrying out a small research project (aimed at developing specific skills) or conducting an individual large-scale research project. The competencies of students are assessed by written tests and by evaluations of the student's performance in group sessions, oral presentations and written reports.

Making judgements
Students are trained in developing a sound and critical attitude on the interpretation of new theoretical concepts and on observational and model data. This training starts in courses (during tutorials and discussion sessions) and continues during research projects. Also, the compulsory attendance of students to a minimum number of seminars and institute colloquia contributes to developing a broad and critical orientation in physics. Students are made explicitly aware of the principles of scientific integrity.

Communication
Being capable of transferring knowledge and/or results of professional activities, both in oral and written form, is crucial to meet the overall aim of the degree programme. This aspect receives ample attention in the programme. Training starts at course level. Many courses include group sessions in which problems are discussed. Also, many courses require students to read several scientific papers, summarise the outcomes in a coherent way to fellow students and write a final report. Both the presentation and the report are discussed with the teaching staff. Furthermore, large research projects always include active participation in the work discussions of the research group, an oral presentation and a final report. Students are stimulated to attend courses and conduct research projects outside Utrecht University. These activities contribute to further development of their communication skills.

Learning skills
The philosophy of the degree programme is that students learn by doing. This means that from the beginning of their study onward, they are confronted with results of ongoing research and scientific debates. In this process, they are challenged by the teaching staff to formulate their own professional opinion and to come up with new creative ideas. These skills are further developed during small and large research projects, during which new hypotheses have to be formulated and verified. In this interactive way students learn that discussion and collaboration are essential elements of modern research in physics.

The graduate of the master's programme in Theoretical Physics:

1. Knowledge and understanding
a) has in-depth knowledge of and insight into field-theoretic and mathematical methods in theoretical physics and its use in high-energy physics and/or condensed matter physics and/or statistical physics; b) is aware of recent developments in theoretical physics, and is able to state the relevance of these developments for the research field and society; c) can read and understand the professional literature in the field of at least one of the following topics: high energy physics, condensed matter physics, statistical physics, and to relate this to his/her own research; d) understands the potential dilemmas related to scientific integrity in his/her research field.
2. Applying knowledge and understanding
a) is able to define, under the supervision of a staff member, a scientific problem in modern theoretical physics, formulate a research question, and design a basic strategy to solve this problem; b) is able to carry out this research plan under supervision of a scientific staff member according to the rules of good experimental practice and ethics, and report on it in a manner that meets the customary standards of the discipline; c) is able to analyse and interpret, under the supervision of a staff member, the acquired results, materials and/or data according to scientific standards.
3. Making judgements
a) is able to participate critically and constructively in the scientific debate in the research group; b) is able to indicate the relevance of his/her research for the advancement of physics; c) can critically reflect on this theoretical-physics research.
4. Communication
a) can explain the results of this research to an audience of specialists as well as fellow students, both orally and in writing, in English; b) can conduct a theoretical-physics research project, supervised by a staff member, possibly as part of a (multidisciplinary) research team.
5. Learning skills
a) has the skills to evaluate his/her own learning and development process and to adjust this process if necessary; has obtained the ability to study focused and independently; b) is able to apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession; c) is qualified to be admitted to a PhD research project in the field of theoretical physics, physics in general, and/or mathematics; is qualified to acquire a research position in a (semi) public or commercial organization; d) has a good idea of the employment possibilities and the skills needed to make a successful start in the labour market.

The graduate of the master's programme in Experimental Physics

1. Knowledge and understanding

a) has in-depth knowledge of and insight into modern experimental physics with an emphasis on at least two of the following topics: Particle Physics (PP), Atomic, Molecular and Optical (AMO) physics, Soft Condensed Matter & Biophysics (SCMB); is aware of recent developments in experimental and data analysis techniques in at least one of the following fields: Particle Physics, Atomic, Molecular and Optical physics, Soft Condensed Matter & Biophysics, and is able to state the relevance of these developments for the research field and society;
b) is aware of recent developments in experimental physics, and is able to state the relevance of these developments for the research field and society;
c) can read and understand the professional literature in the field of at least one of the following topics: Particle Physics, Atomic, Molecular and Optical Physics, Soft Condensed Matter & Biophysics; and to relate this to his/her own research;
d) understands the potential dilemmas related to scientific integrity in his/her research field.

2. Applying knowledge and understanding

a) is able to define, under the supervision of a staff member, a scientific problem in Particle Physics, Atomic, Molecular and Optical physics or Soft Condensed Matter & Biophysics, formulate a research question, and design a basic strategy to solve this problem;
b) is able to carry out this research plan under supervision of a scientific staff member according to the rules of good experimental practice and ethics, and report on it in a manner that meets the customary standards of the discipline;
c) is able to analyse and interpret, under the supervision of a staff member, the acquired results, materials and/or data according to scientific standards.

3. Making judgements

a) is able to participate critically and constructively in the scientific debate in the research group;
b) is able to indicate the relevance of his/her research for the advancement of physics;
c) is able to reflect critically upon his/her own contribution to the research in the selected field (Particle Physics, Atomic, Molecular and Optical physics, or Soft Condensed Matter Physics & Biophysics), and that of others.

4. Communication

a) has the skills to present and discuss, in spoken and written English, the results of research, including the underlying knowledge and background, to a target group composed of specialists or non-specialists;
b) is able to work together in a constructive critical way in an international (possibly interdisciplinary) team of experts and use modern means of scientific communication.

5. Learning skills

a) has the skills to evaluate his/her own learning and development process and to adjust this process if necessary; has the skills to work independently and take initiatives where necessary;
b) is able to apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession;
c) has the qualifications to enrol in a PhD programme in at least one of the following fields: Particle Physics, Atomic, Molecular and Optical physics, Soft Condensed Matter & Biophysics; is qualified to acquire a position as a professional in a (semi) public or commercial organisation;
d) has a realistic idea of the career opportunities after graduating, and of the skills that he/she needs to successfully start a career.

The graduate of the master's programme in Climate Physics:

1. Knowledge and understanding
a) has in-depth knowledge of and insight into the physics of the climate system, i.e. the dynamics of atmosphere, ocean and climate; b) is aware of recent developments in the field of global climate models and of process-oriented models, and is able to state the relevance of these developments for the research field and society; c) can read and understand the professional literature in the field of at least one of the five research themes of the programme, and is able to relate this to his/her own research; d) understands the potential dilemmas related to scientific integrity in his/her research field.
2. Applying knowledge and understanding
a) is able to define, under the supervision of a staff member, a scientific problem in Climate Physics; to formulate a research question, and to design a basic strategy to solve this problem; b) is able to carry out this research plan under supervision of a scientific staff member according to the rules of good experimental practice and ethics, and report on it in a manner that meets the customary standards of the discipline; c) is able to analyse and interpret, under the supervision of a staff member, the acquired results, materials and/or data according to scientific standards.
3. Making Judgements
a) is able to participate critically and constructively in the scientific debate in the research group; b) is able to indicate the relevance of his/her research for the advancement of physics; c) is able to critically reflect on his/her own results, as well as on published scientific literature in the field of climate physics.
4. Communication
a) is able to transfer knowledge and results of scientific research in the field of climate physics to both a specialised and a more broadly interested audience, both in oral and written form; b) is able to professionally act in a (possibly multi-disciplinary and international) research team.
5. Learning skills
a) has the skills to reflect upon his/her learning process and, if necessary, adjust this process; has acquired sufficient scientific knowledge and skills to conduct independent scientific research, or to conduct other discipline-related work; b) is able to apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession; c) has the qualifications to enroll in a PhD programme in Climate Physics; is qualified to acquire a position as a professional in a (semi) public or commercial organisation; d) Has a realistic idea of the career opportunities after graduating, and of the skills that he/she needs to successfully start a career.

APPENDIX 3: OVERVIEW OF THE CURRICULUM

Theoretical Physics

Contents: mandatory courses (30 EC), primary electives (30 EC), secondary electives (15 EC), research (45 EC)

Mandatory courses Learning aims: acquire deep knowledge, insight and competences in the field of theoretical physics.	
Components: -Introducing Natural Sciences (0.5 EC) -Dilemmas to the Scientist (0.5 EC) -Quantum Field Theory (10 EC) -Statistical Field Theory (10 EC) -Student Seminar in Theoretical Physics (9 EC)	Type of work: -oral lectures -tutorials -assignments -literature study -presentations/discussions
Primary electives Learning aims: depending on selection, more specific and extensive knowledge and research competences in either 1) quantum gravity, strings and elementary particles, or 2) condensed matter theory.	
Components (each 7.5 EC): -At least one master level course in Mathematics -Advanced Topics in Theoretical Physics I -Advanced Topics in Theoretical Physics II -General Relativity -Cosmology -String Theory -Modelling and Simulation -Field Theory in Condensed Matter -Soft Condensed Matter theory -Field Theory in Particle Physics -Theory for Technology (with TUE)	Type of work: -oral lectures -tutorials -assignments -literature study -presentations/discussions -self-study
Secondary electives Learning aims: acquire relevant applied and/or fundamental knowledge and competences; orientation on possible future fields of activity; acquire relevant socio-communicative competences.	
Components: -Any MSc course offered by the Graduate School of Natural Sciences. -With the consent of the programme coordinator, also other master level courses may be selected.	Type of work: -various
Research Learning aims: to conduct high-quality scientific research, regarding all its aspects (scientific, methodologic, technical, social), to present its results in oral and written form and to discuss these results with experts.	
	Type of work: -literature study -formulation of hypotheses -investigate hypothesis by theoretical research - reporting

Profile (optional)
Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with a *profile*. Details about the three possible profiles Education, Complex Systems and Applied Data Science, including entry requirements to specific courses, are given in the Education and Exam Regulations (EER) of the Graduate School of Natural Sciences. The THPH student with a profile has no secondary electives and the research part is reduced by 15 EC. It is permitted to combine the research part of the profile Complex Systems (15 EC) with the research part of the regular programme (30 EC), but the two research parts are separately assessed. Remark: if the student fails to successfully complete the profile, the admissible curriculum conditions for the student revert to the regular (120 EC) programme structure.

Experimental Physics

Contents: mandatory courses (22-23.5 EC), primary electives (21.5-23 EC), secondary electives (15 EC), research (60 EC)

Mandatory courses	
Learning aims: acquire deep knowledge, insight and competences in at least two of the following three fields: 1) particle physics, 2) atomic, molecular & optical physics, 3) soft condensed matter & biophysics.	
Components: -Introducing Natural Sciences (0.5 EC) -Dilemmas to the Scientist (0.5 EC) and select 3 courses from the following list: -Particle Physics 1 (6 EC) -Experimental Quantum Physics (7.5 EC) -Photon Physics (7.5 EC) -Soft Condensed Matter Theory (7.5 EC)	Type of work: -oral lectures -tutorials -assignments
Primary electives	
Learning aims: depending on selection, more specific and extensive knowledge and research competences in either 1) particle physics (PP), 2) atomic, molecular & optical physics (AMO), or 3) soft condensed matter & biophysics (SCMB). Type of work: -oral lectures -assignments -presentations/discussions -research -investigate hypothesis by experimental research -tutorials -literature study -self-study	

Components:

Advisory Path →			PP	AMO	SCMB
Course ↓					
Utrecht Courses:					
NS-EX404M	Particle Physics 2	7.5 EC	•		
NS-EX417M	Physics of Light & Electron Microscopy	4.5 EC	•	•	•
NS-EX419M	Application of Light & Electron Microscopy	3 EC	•	•	•
NS-TP432M	Modelling and Simulation	7.5 EC	•	•	•
NS-TP401M	Quantum Field Theory	10 EC	•	•	
NS-TP402M	Statistical Field Theory	10 EC	•	•	•
SK-MASPN	Adv. Spectroscopy of Nanomaterials	7.5 EC			•
SK-MCS	Colloid Science	7.5 EC			•
Shared NIKHEF Master Courses:					
NS-EX430M	Beyond the standard model	3 EC	•		
NS-EX415M	CP violation and Flavor Physics	3 EC	•		
NS-EX432M	Gravitational Waves	3 EC	•		
NS-EX422M	Particle Detection A	3 EC	•		
NS-EX423M	Particle Detection B	3 EC	•		
NS-EX433M	Programming C++	3 EC	•	•	•
NS-EX405M	Computational Methods	6 EC	•	•	•
NS-EX427M	Astroparticle Physics	6 EC	•		
NS-EX434M	Statistical Data Analysis	6 EC	•	•	•
NS-EX429M	Nikhef project	6 EC	•		
NS-EX406M	CERN Summer Student Programme	6 EC	•		

Secondary electives

Learning aims: acquire relevant applied and/or fundamental knowledge and competences; orientation on possible future fields of activity; acquire relevant socio-communicative competences.

Components:	Type of work:
-Any MSc course offered by the Graduate School of Natural Sciences -Internship -Other MSc courses offered by the UU or elsewhere, pending approval from the Board of Examiners	-various

Research

Learning aims: to conduct high-quality scientific research, regarding all its aspects (scientific, methodologic, technical, social), to present its results in oral and written form and to discuss these results with experts.

Type of work:

-literature study
-formulation of hypotheses
-investigate hypothesis by experimental research
- reporting

Profile (optional)
Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with a *profile*. Details about the three possible profiles Education, Complex Systems and Applied Data Science, including entry requirements to specific courses, are given in the Education and Exam Regulations (EER) of the Graduate School of Natural Sciences. The EXPH student with a profile has no secondary electives and the research part is reduced to 45 EC. It is permitted to combine the research part of the profile Complex Systems (15 EC) with the research part of the regular programme (45 EC), but the two research parts are separately assessed. Remark: if the student fails to successfully complete the profile, the admissible curriculum conditions for the student revert to the regular (120 EC) programme structure.

Climate Physics

Contents: mandatory courses (38,5 EC), primary electives (22,5 EC), secondary electives (15 EC), research (44 EC)

Mandatory courses Learning aims: acquire deep knowledge, insight and competences in the field of climate physics	
Components: -Introducing Natural Sciences (0.5 EC) -Dilemmas to the Scientist (0.5 EC) -Dynamical Oceanography (7.5 EC) -Dynamical Meteorology (7.5 EC) -Atmospheric Composition and Chemical Processes (7.5 EC) -Simulation of Ocean, Atmosphere and Climate (7.5 EC) -Making, analyzing and Interpreting Observations (7.5 EC)	Type of work: -oral lectures -tutorials -assignments -literature study -presentations/discussions
Primary electives Learning aims: depending on selection, more specific and extensive knowledge and research competences in either 1) meteorology 2) physical oceanography or 3) atmospheric physics and chemistry.	
Components: Ocean Waves (7.5 EC) Ice and Climate (7.5 EC) Current Themes in Climate Change (7.5 EC) Boundary layers, Transport and Mixing (7.5 EC) Marine Masters Summer Course (3.75 EC) Turbulence in Fluids (7.5 EC) Wave Attractors (7.5 EC) One of the following courses: Morphodynamics of Tidal Systems Morphodynamics of Wave-Dominated Coasts	Type of work: -oral lectures -tutorials -assignments -literature study -presentations/discussions -self-study

<table>
<tr><td colspan="2">Secondary electives

Learning aims: acquire relevant applied and/or fundamental knowledge and competences; orientation on possible future fields of activity; acquire relevant socio-communicative competences</td></tr>
<tr><td>Components:

-At most 15 EC may be chosen from all MSc course offered by the Graduate School of Natural Sciences.
-For other courses approval by the Board of Examiners is required.</td><td>Type of work:

-various</td></tr>
<tr><td colspan="2">Research

Learning aims: to conduct high-quality scientific research, regarding all its aspects (scientific, methodologic, technical, social), to present its results in oral and written form and to discuss these results with experts</td></tr>
<tr><td></td><td>Type of work:

-literature study
-formulation of hypotheses
-investigate hypothesis by research (lab, field, simulation, analytical)
- reporting</td></tr>
<tr><td colspan="2">Profile (optional)

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with a profile. Details about the three possible profiles Education, Complex Systems and Applied Data Science, including entry requirements to specific courses, are given in the Education and Exam Regulations (EER) of the Graduate School of Natural Sciences. The CLPH student with a profile has no secondary electives and the research part is reduced to 29 EC. It is permitted to combine the research part of the profile Complex Systems (15 EC) with the research part of the regular programme (29 EC), but the two research parts are separately assessed.
Remark: if the student fails to successfully complete the profile, the admissible curriculum conditions for the student revert to the regular (120 EC) programme structure.</td></tr>
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APPENDIX 4: PROGRAMME OF THE SITE VISIT

Dinsdag 4 juni

09.00 – 11.00	Welkom en voorbereiding
11.00 – 11.45	**Inhoudelijk verantwoordelijken Natuurkunde**
11.45 – 12.15	Inloopspreekuur
12.15 – 12.45	Lunch
12.45 – 13.45	**Studenten bachelor/master Natuurkunde**
13.45 – 14.15	**Rondleiding**
14.15 – 14.30	Pauze / uitloop
14.30 – 15.30	**Docenten Bachelor/Master Natuurkunde**
15.30 – 15.45	Pauze
15.45 – 16.30	**Examencommissie**
16.30 – 16.45	Pauze
16.45 – 17.15	**Alumni Master Natuurkunde**
17.15 – 18.00	Intern overleg

Woensdag 5 juni

09.00 – 10.00	Aankomst en voorbereiding
10.00 – 10.45	**Inhoudelijk verantwoordelijken HPS**
10.45 – 11.00	Pauze
11.00 – 11.45	**Studenten en alumni HPS**
11.45 – 12.00	Pauze
12.00 – 12.45	**Docenten HPS**
12.45 – 13.30	Lunch / intern overleg
13.30 – 14.15	**Eindgesprek management**
14.15 – 16.00	Opstellen oordelen
16.00 – 16.15	**Mondelinge rapportage**
16.15 – 16.30	Pauze
16.30 – 17.15	**Ontwikkelgesprek**
17.15 – 17.30	Afronding

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

Prior to the site visit, the panel studied 15 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):

- Electronic learning environment master's programme
- Assessment plan Graduate School of Natural Sciences
- Research project application form
- Research project assessment form
- Education and Exam Regulations Graduate School of Natural Sciences
- Rules and regulations of the Board of Examiners
- Data of grades research projects per student number
- Data of students and alumni surveys
- Data of 'Keuzegids Hoger Onderwijs' 2017 and 2018
- Data of teachers surveys
- Documents curriculum evaluations