BACHELOR'S PROGRAMME STERRENKUNDE

FACULTY OF SCIENCE AND ENGINEERING

UNIVERSITY OF GRONINGEN

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This report was finalised on 1 October 2019

REPORT ON THE BACHELOR'S PROGRAMME ASTRONOMY OF UNIVERSITY OF GRONINGEN

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

Bachelor's programme Astronomy

Name of the programme:	Sterrenkunde (Astronomy)
CROHO number:	50205
Level of the programme:	bachelor's
Orientation of the programme:	academic
Number of credits:	180 EC
Specialisations or tracks:	-
Location:	Groningen
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 and Engineering of University of Groningen took place on 13, 14 and 15 May 2019.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

Name of the institution:	University of Groningen
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 bachelor's programme Astronomy 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 the KU Leuven (Belgium);
- Prof. dr. G. (Garrelt) Mellema, professor 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;
- J. (Jeffrey) van der Gucht BSc, master's student Physics and Astronomy at Radboud University [student member].

The panel was supported by dr. B.M. (Barbara) van Balen, who acted as secretary.

WORKING METHOD OF THE ASSESSMENT PANEL

The bachelor's programme Astronomy at the Faculty of Science and Engineering of University of Groningen 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 the 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 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 University of Amsterdam/Vrije Universiteit Amsterdam, and drs. Mariëtte Huisjes was secretary at Radboud University. The project manager and the secretaries regularly discussed the assessment process and outcomes.

Preparation
On 15 March 2019, the panel chair was briefed by the project manager on the tasks and working method of the assessment panel and more specifically its role, as well as use of the assessment framework.

A preparatory panel meeting was organised on 12 May 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 10 students, based on a provided list of graduates between 2017-2018. 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 bachelor's programme Astronomy, this overlap consists of a shared Board of Examiners with the master's programme Astronomy, as well as alignment of assessment procedures with the (Applied) Physics Board of Examiners and an overlap in teaching staff between all six programmes. 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 University of Groningen took place on 13, 14 and 15 May 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, alumni 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 Engineering 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

Standard 1
In the Faculty's vision, astronomy is an empirical science aimed at understanding and describing the universe on the basis of quantitative observations. In line with this vision, the bachelor's degree programme Astronomy aims to produce astronomers and astrophysicists with a solid basic knowledge of astronomy and physics and a fundamental understanding of astrophysical processes, along with a strong foundation of competences, skills and technological know-how.

The programme described intended learning outcomes (ILOs) within the framework of the Dublin Descriptors. The panel established that the ILOs are formulated in line with its vision and mission and sufficiently indicate what could be expected from students at a bachelor's level. The ILOs reflect the content, level and orientation of the bachelor's programme and match the professional field. The panel appreciates that the programme's vision is broader than the boundaries of the discipline and established that this vision is translated into programme objectives leading to a thorough preparation for a successful start to various master's degree programmes while also creating possibilities for a career outside academia. The panel feels, however, that the vision could be more explicit about the link of the discipline to societal goals.

Standard 2
The astronomy curriculum is composed of a core major and a 30 EC minor. The major represents 150 EC, including the bachelor's research project of 15 EC. The level and breadth of the programme gradually shift from basic and broad to more advanced and specialised courses, with continuous attention being paid to acquiring and improving skills. The curriculum is organised along four learning lines: basic physics, basic mathematics, astronomy and skills. A considerable part of the programme consists of mathematics and physics courses followed at the same level as the mathematics and physics students. The programme concludes with a bachelor's research project of 15 EC, which is carried out in one of the research groups at the Kapteyn Astronomical Institute, SRON or ASTRON.

The panel appreciates the room created for a minor, particularly because the size of 30 EC gives the students the opportunity to do it abroad. However, some of the courses in the minor, such as cosmology, are relevant for all students, which forces those who choose another minor to follow these courses on an extracurricular basis. The panel advises that the programme management reconsiders the position of these courses in the curriculum.

Courses are generally taught in the form of lectures, with various levels of student-teacher interactivity. Active participation by the students is promoted and expected in the tutorials and during practical work and other group-based work forms. The panel very much appreciates the strong involvement of the study association and recognises the added value of its additional didactic activities. However, the panel also sees the risk that these educational activities could take the role of skills education that belongs in the core curriculum. It advises the programme management to ensure that the activities offered by the study association remain purely extracurricular in addition to the skills education offered within the programme.

The curriculum is based on well-defined learning lines. The quality of the teaching staff is good. The programme is feasible, as the success rates of the students are in line with the national averages in sciences programmes. The choice to offer the programme in English is sufficiently substantiated according to the panel.

The facilities of the Astronomy programmes are excellent and add to their quality in the panel's opinion. The panel encourages the management of the Faculty to keep these facilities at the same high level.

Standard 3
The programme director drafts an assessment plan annually at the programme level. In addition, a Course Unit Assessment Overview (CUAO) is available for each course. The programme uses different modes of assessment, such as multiple-choice and written exams, assignments, oral exams, presentations, reports and research projects. The preferred assessment method gradually shifts towards methods more suited to assessing higher levels of knowledge and skills, reaching the level of independent creation during the research project.

The panel finds the assessment system and policy adequately developed and implemented. The courses use a variety of assessment methods, which are aligned with the learning outcomes and the curriculum. The procedures are transparent for teachers and students.

The panel is positive about the way the Board of Examiners is performing its tasks. The role of the BoE has obviously been extended and improved in the assessment period. The panel concluded that the examinations, tests and thesis assessment are transparent, valid and reliable. It particularly values the Course Unit Assessment Overviews for all courses.

Standard 4
The panel verified the alignment between programme's intended learning outcomes and the courses and exams in the curriculum. It concluded that this alignment ensures that graduates have achieved the intended learning outcomes. It studied a selection of ten bachelor's theses and their assessments. They showed that the minimum level required for a bachelor's programme astronomy had been reached and often exceeded.

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

Bachelor's programme Astronomy

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, dr. Barbara van Balen, hereby declare that all panel members have studied this report and that they agree with the judgements laid down in the it. They confirm that the assessment has been conducted in accordance with the demands relating to independence.

Date: 1 October 2019

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

The bachelor's degree programme Sterrenkunde (international name: Astronomy) is provided by the Faculty of Science and Engineering of the University of Groningen. This Faculty also offers the bachelor's degree programmes Physics and Applied Physics and the master's programmes Physics, Applied Physics and Astronomy which are also being assessed in this cluster assessment. This report concerns the assessment of the bachelor's degree programme Astronomy; the assessments of the other bachelor's and the master's degree programmes are described in separate reports.

The Faculty of Science and Engineering (FSE) is a large faculty, its programmes in research and education range from nanomaterials and bio-machinery to astronomy and also includes mathematics, pharmacy, neurosciences, computer science and biology. Research at FSE is carried out in a number of institutes. The research institute which is particularly relevant for astronomy is the Kapteyn Astronomical Institute (Kapteyn).

All bachelor's degree programmes of the FSE are organised in the Undergraduate School of Science and Engineering (USSE), which is managed by the director together with the programme directors of the respective programmes.

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
In the Faculty's vision, astronomy is an empirical science aimed at understanding and describing the universe on the basis of quantitative observations. In line with this vision, the bachelor's degree programme Astronomy aims to produce astronomers and astrophysicists with a solid basic knowledge of astronomy and physics and a fundamental understanding of astrophysical processes, along with a strong foundation of the competences, skills and technological know-how necessary to pursue a career in astronomical research, and specifically to prepare the students for the master's degree programme in astronomy. The future generation of astronomers should be able to operate beyond and across disciplinary boundaries, according to the programme management. The bachelor's programme Astronomy of the University of Groningen is one of two Astronomy bachelor's programmes offered in the Netherlands (the other one is offered by Leiden University). The University of Groningen, together with the space scientists of SRON, located in the same building, has one of the largest concentration of astronomers in the Netherlands. In the panel's view, this gives the programme a good position. The programme obviously fulfils a need: the student intake increased from 19 in 2013 to 69 in 2018.

The programme described intended learning outcomes (ILOs) within the framework of the Dublin Descriptors (see Appendix 2). The panel established that the ILOs are formulated in line with the mission and sufficiently indicate what could be expected from students at a bachelor's level. The ILOs reflect the content, level and orientation of the bachelor's programme and match the professional field. The distinction between the ILOs of the bachelor's and the master's programme is clear. The programme has aligned its intended learning outcomes with the domain-specific reference framework (Appendix 1). This framework is used by all Physics and Astronomy programmes in the Netherlands. It was developed in a joint process at the European level (Tuning Physics) to align the Physics and Astronomy programmes at an international level. The ILOs use the Dublin descriptors to describe the knowledge, insights and skills that each bachelor's student in either Physics or Astronomy should acquire, regardless of his or her specialisation. The panel established that there is an alignment of the Physics and Astronomy programmes at a European level.

The programme is primarily designed to prepare students for enrolling in a follow-up master's degree programme in Astronomy and adjacent fields. It also allows alumni to start a career outside academia. According to the management, the programme is a good preparation for a non-academic career through its emphasis on frequently sought-after analytical and problem-solving skills, combined with state-of-the art computational skills.

Considerations
The panel concluded that the ILOs of the bachelor's degree programme Astronomy meet the Dutch qualification framework and the international standards as indicated by the alignment with the domain-specific framework for Physics, Applied Physics and Astronomy. They sufficiently indicate the academic bachelor's level.

The panel appreciates that the vision of the programme is broader than the boundaries of the discipline and established that this vision is translated into programme objectives leading to a thorough preparation for a successful start of various master's degree programmes and also creates possibilities for a career outside academia.

Conclusion
Bachelor's programme Astronomy: 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
The Astronomy curriculum is composed of a core major and a 30 EC minor. The major represents 150 EC, including the bachelor's research project of 15 EC. The level and breadth of the programme gradually shift from basic and broad to more advanced and specialised courses, with continuous attention being paid to acquiring and improving skills. The curriculum is organised along four learning lines:

- Basic physics: Mechanics & Relativity, Electricity & Magnetism, Thermodynamics & Statistical Physics, Quantum Physics, Waves & Optics, and Structure of Matter;
- Basic mathematics: Calculus 1+2, Linear Algebra 1, Mathematical Physics, and Complex Analysis;
- Astronomy: Observational Astronomy, Statistics for Astronomy, Numerical Methods, Physics of Galaxies, Physics of Stars, Astroparticle Physics, Astrophysical Hydrodynamics, and Interstellar Medium.
- Skills: Physics Laboratory 1, Introduction Programming and Computational Methods, Observational Astronomy, Physics, Astronomy, Ethics & Society, and the bachelor's research project.

A considerable part of the programme consists of mathematics and physics courses followed at the same level as mathematics and physics students. Teaching the required basic mathematics is concentrated in the first half of the programme. Basic physics subjects are predominantly offered as 10 EC courses that run for a full semester. The skills training covers both academic and research skills and runs through the entire programme. Skills are not only taught in dedicated courses, they are also integrated in disciplinary courses and in the research project. An overview of the programme is included in Appendix 3.

The main goals of the first year are orientation, selection and basic education. The content and level of the first year are representative of the programme as a whole. Many courses are shared with the bachelor's programmes Physics and Applied Physics to facilitate the possibility to switch programmes. The Introductory Astronomy elective scheduled in the first year is followed by the vast majority of astronomy students. The practical Introduction to Programming and Numerical Methods course provides students with essential computer programming skills in Python. The Observational Astronomy course deals with practical aspects of optical observational astronomy. The second year contains the Physics of stars and Physics of galaxies courses. The third year consists of two quarters dedicated to a minor and two quarters with courses for the major. Students can choose between a deepening physics minor, the Astronomy minor and the Instrumentation and Informatics minor. Students can also choose from about 30 broadening minors offered within the University of Groningen or by other universities in the Netherlands or abroad. Most students take the minor programme in Astronomy. The astronomy courses in the third quarter of the third year are largely directed towards the theoretical understanding of the physics involved in astronomical phenomena and processes.

The programme concludes with a bachelor’s research project of 15 EC. The research is carried out in one of the research groups at the Kapteyn Astronomical Institute or the NWO institutes SRON or ASTRON, where the student conducts supervised but independent and individual research in a master-apprentice relationship with the supervisor. At the end of the project, the student writes a thesis based on his or her work. All students present their research at the Bachelor symposium, in front of a public composed of supervisor, examiners, faculty members, and peers.

In reaction to remarks made by students in the self-evaluation report, the panel discussed the position of the minor in the curriculum with the programme representatives. The minor courses contain a lot of important and useful information on cosmology, radio astronomy, high-energy astrophysics and mechanics, and students who do not follow the minor miss out on a lot of useful information. Some students mentioned that they somehow feel forced to choose this minor. The staff agrees that the minor contains some courses that are in fact relevant for all astronomy students, and also for some physics students, but in their view it is possible to choose another (smaller) minor of 15 EC and do these specific courses as well. The reason to include courses like Cosmology in the minor is to enable Physics students to take these courses.

In principle, the panel appreciates the room created in the curriculum for a minor, particularly since the size of 30 EC also gives the students the opportunity to go abroad. However, not all students feel free to take this opportunity, as the Astronomy minor contains courses relevant to them. As a result, they feel forced to choose the Astronomy minor or follow its courses in an extracurricular manner. The panel advises the programme management to reconsider the position of some of the courses in the astronomy minor to make them available to all students without sacrificing opportunities to follow a broadening minor.

Students are in general very satisfied with the curriculum. They appreciate the focused training in computer skills. The skills they acquire in this training turn out to be very useful for their future career. However, they feel that the training in other skills, like presenting, academic writing and group work, lags behind. The panel agrees with the students and notes that the Skills learning line mainly focuses on technical skills. It advises the programme to strengthen training of these non-technical skills in the Skills learning line.

Astronomy is a closely knit community with short links between the teaching staff and the students. Students are involved in the research groups from an early stage in the curriculum. The astronomy students have a very active study association which organises rehearsal and practice sessions for exams, company visits and talks by the industry. Almost all students, both national and international, are active in the study association. The fact that astronomy is housed in its own building with its own facilities also adds to a sense of community. In the first semester of the first year, students are placed in mentor groups. These mentor groups support the students to get acquainted with university teaching and learning and are aimed at group building and developing study skills. Student numbers are increasing; student enrolment in the bachelor’s programme increased from 19 in 2013 to 69 in 2018. This increase is a challenge for the community feeling as well as for the facilities and the housing.

The panel finds the curriculum to be well-developed, managed and implemented, and there is a good alignment between it and the intended learning outcomes. It appreciates the coherent learning lines in the programme and established that there is ample attention paid to the development of skills.

The University of Groningen chose to offer the programme in English with the aim to create an international academic environment, with the goal of adapting the students to the dominant modes of communication in science and thereby preparing students for their future career. This choice is sufficiently substantiated according to the panel.

Teaching forms
Courses are generally taught in the form of lectures and tutorials, with various levels of student-teacher interactivity. Active participation by the students is promoted and expected in the tutorials and during practical work and other group-based work forms. A substantial part of the astronomy curriculum concerns courses aimed at practising computer tasks, computer simulations, astronomical observations and data analysis. These tasks are typically executed in small groups of two or three students. In the individual bachelor’s research project, students experience the full cycle of scientific research and show that they are able to carry out the full process of scientific research with a modest level of supervision.

Teamwork and collaboration also figure strongly in a range of extracurricular astronomy-related activities in which all bachelor’s students get involved. As mentioned above, the study association organises rehearsal and practice sessions for exams. Students are also involved as volunteers in the active outreach programme of the Kapteyn Astronomical Institute. It integrates them in the institute and provides an excellent platform for working in a team and developing presentation and dissemination skills. The panel very much appreciates this strong involvement of the study association in the institute and recognises the added value of these activities, considering the fact that the students are involved in the organisation. However, it also sees the risk that these educational activities could take the role of skills education that belongs in the core curriculum. It advises the programme management to ensure that the activities offered by the study association remain purely extracurricular in addition to the skills education offered within the programme.

Feasibility
The academic year is divided into two semesters, each divided into two periods of eight instruction weeks followed by two exam weeks. In every period three course components of 5 EC are taught. The nominal workload for students is 40 hours per week. The panel discussed the feasibility of the programme with both the teachers and the students. The students did not indicate any specific obstacles in the curriculum and are satisfied with the feasibility. However, the success rate of the programme could be improved: 60% of the students obtain their bachelor’s diploma within 4 years. The programme management aims at 70% in four years. The panel concluded that there are no obstacles in the programme that hinders the students from finishing their studies in time.

Staff
The tenured staff members contributing to the programme all have a PhD degree and are actively involved in research in the Kapteyn Astronomical Institute. Some 75% of the active teaching staff has acquired a University Teaching Qualification (UTQ). According to the self-evaluation report the Kapteyn staff represents all necessary scientific expertise to take care of the astrophysics courses in the bachelor’s programme. The physics courses are taught by staff members of the Van Swinderen Institute, the Zernike Institute, ESRIG and KVI-Cart. The mathematics courses are mostly taught by staff members of the Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence. PhD students and postdocs are also involved in teaching, mainly as teaching-assistants for tutorials. In the next academic year a mandatory didactical training for PhD students and postdocs will be offered.

The students are positive about the teachers and report that they are accessible, very willing to help and to answer questions. They are also very positive about the added value of the academic advisor;

she knows how to get things done and helps students with their planning. The English language proficiency of all tenured staff is considered sufficient to good. The teaching staff is very positive about the benefits of the international programme and the use of one consistent teaching language.

The panel established that the bachelor's programme is taught by experts strongly connected to research and that a high proportion of the tenured staff has sufficient didactical training. The proficiency in English of all tenured teacher staff is sufficient.

Facilities

The University of Groningen has a modest astronomical observatory on the Zernike complex. This is one of the largest optical telescopes in the Netherlands and is used as a teaching platform for astronomy students to learn how to observe the night sky in a professional setting. During the site visit the panel visited the Kapteyn institute, saw the work spaces and the lecture rooms, got an introduction in the use of the dedicated computer facilities and toured the observatory. It confirmed that the Astronomy degree programmes have excellent facilities. The facilities for the students enable them to be part of the scientific community. The housing of the Kapteyn Institute and the dedicated facilities add to the quality of the programme, in the panel's opinion. The students mentioned in the self-evaluation report that the facilities offered by the university are very good. The servers and computers of the Kapteyn Institute are very good, and the assistance from the secretaries and computer group is excellent. Due to the increasing student numbers, however, the amount of working space for students can become a problem. The panel thinks that efforts should be made to keep the facilities on the same level despite the increasing student numbers.

Considerations

The curriculum of the bachelor's programme Astronomy enables the students to achieve the intended learning outcomes. The panel found the curriculum to be well developed, managed and implemented, and there is a good alignment between it and the intended learning outcomes.

The panel established several positive aspects in the teaching-learning environment. It appreciates that the bachelor's programme is offered by experts who are strongly connected to the Kapteyn Institute. The curriculum is based on well-defined learning lines. The panel appreciates the option to choose a substantive minor of 30 EC, but it advises the programme management to reconsider the position of those courses in the minor timeslot in the curriculum that are relevant for almost all astronomy students.

The training in technical skills, in particular computer skills, is extensive, focused and well appreciated. The training in other, non-technical skills, like academic writing, presentation and group work, could be developed more. The panel advises strengthening these skills in the skills training line.

A very strong aspect of the astronomy programme is the basis in a vibrant academic community and the extensive involvement of the study association. However, the panel also sees the risk that these educational activities could take the role of skills education that belongs in the core curriculum. It advises the programme management to ensure that the activities offered by the study association remain purely extracurricular in addition to the skills education offered within the programme.

The quality of the teaching staff is good, the students are positive about their quality and dedication. The university has an adequate UTQ policy and good intensive training programmes to enhance the didactic quality of the teaching.

The panel also appreciated that there is a mentoring system and that the students are closely followed in the first semester of the first year to support their transition from secondary school to university. The programme is feasible, and the success rates of the students are in line with the national averages in sciences programmes.

The choice to offer the programme in English is sufficiently substantiated according to the panel.

Conclusion
Bachelor's programme Astronomy: 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 policy
An assessment plan is drafted annually by the programme director and approved by the Faculty Board. It consists of a list of examiners, modes of assessment of all course units, a list of individual Research Project supervisors, and a matrix clarifying the relationship between the learning outcomes of the course units and the final learning outcomes of the degree programme. In addition to this assessment plan at the programme level, a Course Unit Assessment Overview (CUAO) is available for each course. This overview is a systematic description of the links between the learning outcomes, modes of instruction and modes of assessment and grading, and the position of the course in the curriculum. These overviews are updated annually. A summary of the CUAO is made available to the students. The panel studied several CUAOs during the site visit. It is very positive about these overviews.

The programme uses different modes of assessment, such as multiple-choice and written exams, assignments, oral exams, presentations, reports and research projects. The preferred assessment method throughout the curriculum gradually shifts towards ones more suited to assessing higher levels of knowledge and skills, reaching the level of independent creation during the research project.

As a rule, exams and assignments of course units are always drafted or checked by two lecturers (peer review). Individually supervised course units, like the bachelor's research project, are assessed using a standard assessment form. Furthermore, at least two examiners are involved: the supervisor and a second examiner. The process is guided and monitored by the bachelor's project coordinator, who also takes care of the calibration of the grades with respect to the whole cohort and those of previous years. The panel has seen the assessment forms used for the bachelor's research project and discussed the use of this form as well as the procedure followed by the examiners with the teachers and the Board of Examiners during the site visit. It noticed that there is no grading rubric included in the form and that some of the completed forms lacked motivation for the grades. The students did inform the panel that they received extensive oral feedback on their bachelor's theses and that they were quite satisfied with that. The panel would, nevertheless, recommend formalising motivation of the grading on paper. The panel finds the assessment system and policy adequately developed and implemented.

Board of Examiners
Since the last programme assessment, several actions have been taken to strengthen the role and task performance of the Board of Examiners (BoE). The BoE is responsible for ensuring the quality of examinations and final assessments. The BoE for the bachelor's and master's degree programmes Astronomy consists of four members, chosen from the teaching staff, and one external member. The BoE checks whether the Assessment Plan is appropriate for the intended learning outcomes of the programme, whether the suggested examiners are qualified for their role, whether there is sufficient variety in the modes of assessment, and whether they are appropriate for the specific learning outcomes.

To check the assessment of the research projects, the BoE annually reviews at least 8 theses. Priority is given to theses with grades 6, 6.5 or 9 and higher. In the last assessment period the BoE generally agreed with the marks awarded by the supervisors. One aspect of improvement identified by the BoE was that the supervisors could elaborate more on the justification of grades on the assessment form. This aspect was also noted by the panel, as described above.

The CUAO is an important instrument for the BoE to check the quality of the assessments of the course units. To ensure the quality of examinations, the BoE checks the assessments of about eight course units annually. The panel is positive about the way the BoE is performing its tasks. Its role has obviously been extended and improved in the assessment period. The panel concluded that the examinations, tests and the thesis assessment are transparent, valid and reliable.

Considerations
The panel finds the assessment system and policy adequately developed and implemented. The courses use a variety of assessment methods, which are aligned with the learning outcomes and the curriculum. The procedures are transparent for teachers and students.

The panel is positive about the way the Board of Examiners is performing its tasks. Its role has obviously been extended and improved in the assessment period. The panel concluded that the examinations, tests and the thesis assessment are transparent, valid and reliable.

The panel particularly values the Course Unit Assessment Overviews (CUAOs) for all courses.

Conclusion
Bachelor's programme Astronomy: 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
The self-evaluation report indicated that the bachelor's programme Astronomy guarantees that students are educated regarding knowledge, skills, and attitude as specified in the learning outcomes by presenting a matrix of the intended learning outcomes and the curriculum. The panel verified this matrix and concluded that the curriculum ensures that graduates have achieved the intended learning outcomes. It studied a selection of ten bachelor's theses and their assessments. The theses showed that the graduates are capable of drawing up a research question and designing, planning and conducting research. They demonstrated that they are able to report on their research, are aware of the societal, ethical and social aspects of their subject, and are able to write the report in English. The theses revealed that the minimum level required for a bachelor's programme Astronomy had been exceeded.

According to the self-evaluation report, the majority of the bachelor's graduates continue their studies with the master's programme Astronomy in Groningen. The alumni of the bachelor's programme felt well prepared for their master's programme.

The theses demonstrated that the minimum level required for a bachelor's programme in Astronomy had been reached and in many cases had been exceeded.

Considerations
The panel concluded that graduates of the bachelor's programme in Astronomy have achieved the intended learning outcomes. The minimum level has been reached and often exceeded. The panel concluded that the programme leads to an internationally competitive level. The panel found the level of the bachelor's theses to be good. The graduates are well prepared for continuing their study in a master's programme.

Conclusion
Bachelor's programme Astronomy: the panel assesses Standard 4 as 'meets the standard'.

GENERAL CONCLUSION

The panel judged that the bachelor's programme in Astronomy offered by the University of Groningen meets all standards of the NVAO assessment framework for a limited programme assessment. It therefore recommends accreditation of the programme.

Conclusion
The panel assesses the *bachelor's programme Astronomy* 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.

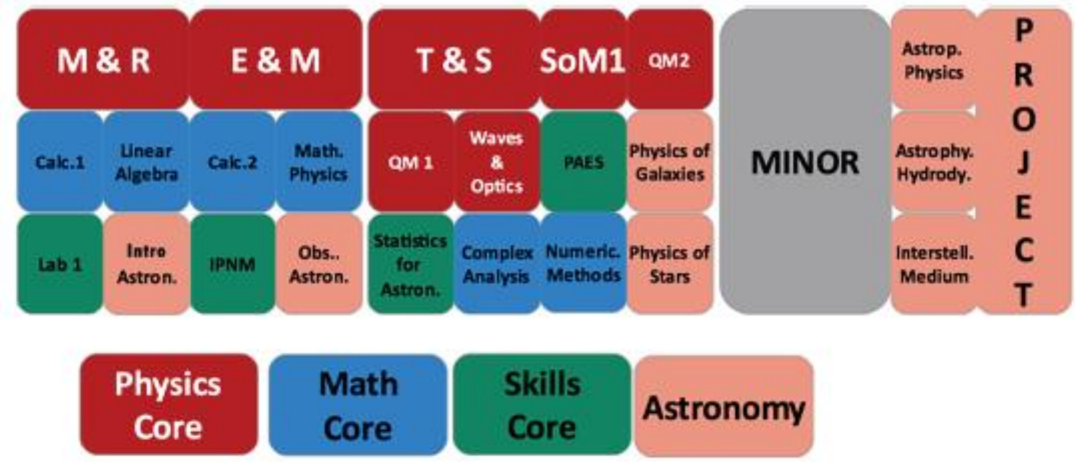
(E) Learning

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

Dublin-descriptors	Learning outcomes	
Alumni of the programme have:		
1. Knowledge and understanding	A1	general knowledge of the foundations and history of mathematics, natural sciences and technology, in particular those of astronomy and astrophysics.
	A2	mastered the basic concepts of Astronomy and Astrophysics are familiar with the interrelationships of these concepts within their own discipline as well as with other disciplines.
	A3	in-depth knowledge of several contemporary topics within Astronomy and Astrophysics.
	A4	familiarity with the quantitative character of the fields of mathematics and natural sciences and an understanding of the methods used in these fields, and particularly within Astronomy and Astrophysics, including computer-aided methods.
	A5	sufficient knowledge and understanding of mathematics and natural sciences to successfully complete a follow-up Master's degree programme in Astronomy and Astrophysics.
Alumni of the programme are able to:		
2. Applying knowledge and understanding	B1	draw up a research question, design, plan and conduct research and report on it independently with an appropriate degree of supervision. Bachelor's graduates are able to evaluate the value and limitations of their research and assess its applicability outside their own field.
	B2	translate an astronomy and astrophysics problem into a plan of approach and – taking into account practical boundary conditions – find a solution.
	A4	understand the quantitative character of the fields of mathematics and natural sciences and understand the methods used in these fields, and particularly within Astronomy and Astrophysics, including computer-aided methods.
Alumni of the programme are:		
3. Making judgements	A6	aware of the societal, ethical and social aspects involved in the fields of mathematics and natural sciences, and act accordingly.
	B4	able to collaborate in teams on technical-scientific problems.
	B6	able to assess their own actions and those of others in a natural sciences context, bearing in mind the social/societal and ethical aspects.
Alumni of the programme are able to:		
4. Communication	B5	communicate in English, both orally and in writing, in academic and professional contexts, with both colleagues and others. They are familiar with the relevant means of communication.
	B3	gather relevant information using modern means of communication and to critically interpret this information.
Alumni of the programme are able to:		
5. Learning skills	B7	apply learning skills that enable them to pursue a follow-up degree and acquire knowledge in new fields with a high level of autonomy.

APPENDIX 3: OVERVIEW OF THE CURRICULUM



Basic physics subjects are predominantly offered as 10 ECTS courses (since 2016-2017) that run for a full semester, rather than the usual 5 ECTS per half-semester.

The four learning lines are:

- Basic Physics: Mechanics & Relativity, Electricity & Magnetism, Thermodynamics & Statistical Physics, Quantum Physics, Waves & Optics, and Structure of Matter;
- Basic Mathematics: Calculus 1 and 2, Linear Algebra 1, Mathematical Physics, and Complex Analysis; in Physics Laboratory 1 elements of Statistics in the context of Error Analysis;
- Astronomy: Observational Astronomy, Statistics for Astronomy, Numerical Methods, Physics of Galaxies, Physics of Stars, Astroparticle physics, Astrophysical Hydrodynamics, and Interstellar Medium;
- Skills: Physics Laboratory 1, Introduction Programming and Computational Methods, Observational Astronomy, Physics, Astronomy, Ethics & Society, BSc research project.

APPENDIX 4: PROGRAMME OF THE SITE VISIT

12 May 2019
17.00 – 19.00 Internal panel meeting

13 May 2019
09.00 – 09.15 Arrival and welcome
09.15 – 09.45 Internal panel meeting
09.45 – 10.45 Management bachelor + master Physics + Applied Physics
10.45 – 11.00 Break
11.00 – 11.45 Bachelor and master students Physics
11.45 – 12.00 Break
12.00 – 12.45 Teaching staff Physics
12.45 – 13.30 Lunch + internal panel meeting
13.30 – 14.15 Show cases, poster presentations by students
14.15 – 14.30 Break
14.30 – 15.15 Bachelor and master students Applied Physics
15.15 – 15.30 Break
15.30 - 16.15 Teaching staff Applied Physics
16.15 – 16.30 Break
16.30 – 17.15 Board of Examiners Physics and Applied Physics
17.15 – 17.30 Break
17.30 – 18.15 Alumni + External Advisory Panel (combined)
18.15 – 18.45 Visit to the observatory

14 May 2019
09.00 – 09.45 Internal panel meeting (overleg)
09.45 – 10.30 Management bachelor + master Astronomy
10.30 – 10.45 Break
10.45 – 11.30 Bachelor and master students Astronomy
11.30 – 11.45 Break
11.45 – 12.30 Teaching staff Astronomy
12.30 – 13.00 Lunch
13.00 – 13.30 Consultation hour
13.30 – 14.15 Tour of the facilities and poster presentation students
14.15 – 14.30 Break
14.30 – 15.15 Board of Examiners Astronomy
15.15 – 16.00 Internal panel meeting preparation meeting with formal management
16.00 – 17.00 Formeel management (combined)

15 May 2019
09.00 – 12.00 Concluding panel meeting, formulating judgements
12.00 – 12.15 Preliminary feedback
12.15 – 12.30 Break
12.30 – 13.30 Development Dialogue (combined) – including lunch

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

Prior to the site visit, the panel studied 10 theses of the bachelor's programme Astronomy. 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):

- Course Unit Assessment Overviews of a sample of courses
- Study Handbooks
- Internship reports, including the assessment forms
- Exemplary journal articles used in the courses
- Year reports of the Boards of Examiners and the Programme Committees
- Quality Assurance Manuals