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# **Appendices to the Teaching and Examination Regulations**

**2023-2024**

## **Master's degree programme in Astronomy**

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- I. Learning outcomes
- II. Tracks/specializations
- III. Content of the degree programme
- IV. Electives
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## Appendix I Teaching outcomes of the degree programme (art. 3.1)

The master graduate in Astronomy:

### 1. Knowledge and understanding

- 1.1. masters the fundamental astronomical and astrophysical concepts as well as the necessary tools from physics, mathematics and computer science, including modeling skills, at a level which permits admission to a PhD programme;
- 1.2. is familiar with the quantitative character of astronomy and astrophysics and with the relevant research methods;
- 1.3. who has completed
  - the Quantum Universe track has operational knowledge in i) an observational or theoretical astronomical or astrophysical subarea, ii) the area of instrumentation and information technology in astronomy, physics, and/or space research, or iii) the area of data science in astronomy, as well as knowledge of the state-of the art in at least one specific research area;
  - the Business, Science and Policy track has operational knowledge of and insight into the functioning of companies and administrations, as well as the relevant legislation and knowledge of the state-of the art in at least one specific research area;

### 2. Application of knowledge and understanding

- 2.1. is capable of carrying out research, aimed at understanding of astronomical phenomena, both observational and theoretical;
- 2.2. is capable of analyzing a (new) complex astrophysical problem, and to use modelling skills to develop a structured and well-planned research approach;
- 2.3. is capable of applying acquired specific knowledge and mathematical, experimental, and computer skills to solve astronomy problems in the relevant subject area, as well as related subject areas and fields;
- 2.4. is capable of collaborating in a (multi-disciplinary) team and has basic skills to manage a (collaborative) project;

### 3. Assessment

- 3.1. is capable of obtaining relevant information using modern information channels, and of interpreting this information critically in the context of an absolute standard;
- 3.2. is capable of managing and assessing personal and others' actions within a highly scientific and professional context, taking societal and ethical aspects into account;
- 3.3. is able of drawing conclusions on the basis of limited or incomplete information, and is able to realize and formulate the limitations of such conclusions;
- 3.4. is acting and conducting research according to the VSNU Code of Conduct for Academic Practice

### 4. Communication skills

- 4.1. is capable of communicating clearly in English, both verbally and in writing, on the subject and relevant applications, at a level which is understandable to experts and non-experts, and using modern communication tools;

### 5. Learning skills

- 5.1. is capable of addressing issues inside as well as outside the main subject area, therefore and thereby gaining new knowledge and skills.



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## **Appendix II Tracks of the degree programme (art. 3.6)**

1. The Master's degree programme in Astronomy offers the following tracks:
  - Quantum Universe
  - Science, Business and Policy
  
2. Within the Quantum Universe track, the following specializations are offered:
  - Theoretical and Observational Astronomy
  - Instrumentation and Informatics
  - Data Science



### Appendix III Content of the degree programme (art. 3.8)

The assessment method(s) of the courses below, including information on practicals, can be found in the assessment plan of the degree programme and on Ocasys.

#### Quantum Universe: Theoretical and Observational Astronomy

Course unit (course code)	ECTS	Entry Requirements
Astronomy colloquium (WMAS001-00)	-	
Electrodynamics of Radiation Processes (WMAS008-05)	5	
General Relativity (WMPH009-05)	5	
Particle Physics Phenomenology (WMPH026-05)	5	
Student seminar Quantum Universe (WMPH039-05)	5	
<i>Astrophysics Core Courses</i>	20	see app. IV
<i>Optional Courses in Theoretical and Observational Astronomy</i>	20	see app. IV
Master Research Project Astronomy (WMAS901-60)	60	

#### Quantum Universe: Instrumentation and Informatics

Course unit (course code)	ECTS	Entry Requirements
Astronomy colloquium (WMAS001-00)	-	
Electrodynamics of Radiation Processes (WMAS008-05)	5	
General Relativity (WMPH009-05)	5	
Particle Physics Phenomenology (WMPH026-05)	5	
Student seminar Quantum Universe (WMPH039-05)	5	
<i>Astrophysics Core Courses</i>	20	see app. IV
<i>Optional courses in Instrumentation and Informatics</i>	20	see app. IV
Industrial Internship (WMPH004-20)	20	
Master Research Project Astronomy (WMAS902-40)	40	

#### Quantum Universe: Data Science

Course unit (course code)	ECTS	Entry Requirements
Astronomy colloquium (WMAS001-00)	-	
Electrodynamics of Radiation Processes (WMAS008-05)	5	
General Relativity (WMPH009-05)	5	
Introduction to Data Science (WMCS002-05)	5	
Particle Physics Phenomenology (WMPH026-05)	5	
Statistical Signal Processing (WMAS011-05)	5	
Student seminar Quantum Universe (WMPH039-05)	5	
<i>Astrophysics Core Courses</i>	20	see app. IV
<i>Optional Courses in Data Science</i>	10	see app. IV
Master Research Project Astronomy (WMAS901-60)	60	



**Science, Business and Policy**

Course unit (course code)	ECTS	Entry Requirements
Astronomy colloquium (WMAS001-00)	-	
Choice * - <i>Astrophysics Core Courses</i> - <i>Quantum Universe Core Courses</i> † - <i>Optional Courses in Theoretical and Observational Astronomy</i>	30	see app. IV see app. III see app. IV
Master Research Project Astronomy (WMAS902-30)	30	
Introduction Science and Business (WMSE001-10)	10	
Introduction Science and Policy (WMSE002-10)	10	
Work placement Business & Policy (WMSE902-40)	40	The student must have successfully completed "Introduction Science and Business" (WMSE001-10), "Introduction Science and Policy" (WMSE002-10), and "Physics Master Research project (SBP)" (WMPH005-30).

\* Courses with credits adding up to 30 ECTS must be selected.

† Quantum Universe Core Courses are: Electrodynamics of Radiation Processes, General Relativity, Particle Physics Phenomenology, Student seminar Quantum Universe.



## Appendix IV Electives (art. 3.9.1)

The assessment method(s) of the courses below, including information on practicals, can be found in the assessment plan of the degree programme and on Ocasys.

### Astrophysics Core Courses

Course unit (course code)	ECTS	Entry Requirements
Formation and Evolution of Galaxies (WMAS005-05)	5	
Astroparticle Physics (WMAS027-05)	5	
Astronomical Data Science (WMAS007-05)	5	
<b>Biennial courses, offered in 2023-2024</b>		
Astrochemistry (WMAS018-05)	5	
Cosmic Structure Formation (WMAS004-05)	5	
Dynamics of Galaxies (WMAS014-05)	5	
Stars, Nucleosynthesis and Chemical Evolution (WMAS010-05)	5	
Exoplanets (WMAS026-05)	5	
<b>Biennial courses, offered in 2024-2025</b>		
Star and Planet Formation (WMAS017-05)	5	
High-Energy Astrophysics (WMAS006-05)	5	

### Capita Selecta Courses

Course unit (course code)	ECTS	Entry Requirements
<b>Biennial courses, offered in 2023-2024</b>		
Dark Matter Detection (WMAS023-03)	3	
Gas Flows in Galaxies (WMAS021-03)	3	
Gravitational Lensing (WMAS026-03)	3	
Stellar Populations in Galaxies (WMAS027-03)	3	
<b>Biennial courses, offered in 2024-2025</b>		
Dwarf Galaxies (WMAS020-03)	3	
Galactic Archaeology in the Milky Way (WMAS024-03)	3	
Gas Flows in Galaxies (WMAS021-03)	3	
HI in Galaxies (WMAS009-03)	3	
Interferometry (WMAS015-03)	3	
Mergers in Galaxy Formation (WMAS016-03)	3	

The capita selecta courses for 2023/2024 are not yet known. Courses are not decided on by the degree programme this far in advance.



**Optional Courses in Quantum Universe: Theoretical and Observational Astronomy**

Course unit (course code)	ECTS	Entry Requirements
Applied Optics (WMME010-05)	5	
Basic Detection Techniques (WMAS002-05)	5	
Computational Physics (WMPH007-05)	5	
Elementary Particle Physics (WMPH034-05)	5	
Fundamental Constants (WMPH008-05)	5	
Introduction to Plasma Physics (WMPH035-05)	5	
La Palma Observation Trip (WMAS012-05)	5	
Lie Groups in Physics (WMPH011-05)	5	
Mathematical Methods of Physics (WMPH016-05)	5	
Nuclear Astrophysics (WMPH038-05)	5	
Quantum Experiments (WMPH017-05)	5	
Quantum Field Theory (WMPH018-05)	5	
Statistical Methods in Physics (WMPH030-05)	5	
Statistical Signal Processing (WMAS011-05)	5	
Basiscursus Master Lerarenopleiding (TEM0105)	5	
Masterstage 1 (TEM0205)	5	
Astronomical Data Science (WMAS007-05)	5	
<b>Biennial courses, offered in 2023-2024</b>		
Geometry and Topology (WMMA018-05)	5	
Particle Cosmology (WMPH025-05)	5	
<b>Biennial courses, offered in 2024-2025</b>		
Active Galaxies and AGN (WMAS022-05)	5	
Geometry & Differential Equations (WMMA017-05)	5	
Gravitational Waves (WMPH022-05)	5	

For the specialization Theoretical and Observational Astronomy (Quantum Universe) a maximum of 20 ECTS may be chosen from the option groups in the table above or from the Capita Selecta Courses, listed below. For the specialization Science, Business and Policy a maximum of 10 ECTS may be chosen from the option groups in the table above or from the Capita Selecta Courses, listed below. For both specialisations, though, no more than three Capita Selecta Courses may be selected.



**Optional Courses in Quantum Universe: Instrumentation and Informatics**

Course unit (course code)	ECTS	Entry Requirements
Advanced Detection Techniques (WMME005-05)	5	
Advanced Instrumentation and Extreme Environments (WMME006-05)	5	
Applied Optics (WMME010-05)	5	
Systems Engineering (WMIE021-05)	5	
Opto-mechatronics (WMME015-05)	5	
Basic Detection Techniques (WMAS002-05)	5	
Control Engineering (WBIE034-05)	5	
Device Physics (WBPH037-05)	5	
Imaging Techniques in Radiology 1 (WBBE012-05)	5	
La Palma Observation Trip (WMAS012-05)	5	
Mechatronics (WBIE011-05)	5	
Numerical Mathematics 2 (WBMA023-05)	5	
Robotics (WMIE005-05)	5	
Scientific Visualization (WMCS018-05)	5	
Statistical Signal Processing (WMAS011-05)	5	
Basiscursus Master Lerarenopleiding (TEM0105)	5	
Masterstage 1 (TEM0205)	5	
<b>Biennial courses, offered in 2023-2024</b>		
Particle Cosmology (WMPH025-05)	5	
<b>Biennial courses, offered in 2024-2025</b>		
Active Galaxies and AGN (WMAS022-05)	5	
Gravitational Waves (WMPH022-05)	5	

For the specialization Instrumentation & Informatics a maximum of 20 ECTS may be chosen from the option groups in the table above or from the Capita Selecta Courses, listed below. Though no more than three Capita Selecta Courses may be selected.





**Optional Courses in Quantum Universe: Data Science**

<b>Course unit (course code)</b>	<b>ECTS</b>	<b>Entry Requirements</b>
Image Processing (WMCS008-05)	5	
Information Systems (WMCS009-05)	5	
La Palma Observation Trip (WMAS012-05)	5	
Machine learning (WMAI010-05)	5	
Modelling and Simulation (WMCS003-05)	5	
Neural Networks and Computational Intelligence (WMCS010-05)	5	
Pattern Recognition (WMCS011-05)	5	
Robotics for AI (WMAI011-05)	5	
Scalable Computing (WMCS017-05)	5	
Scientific Visualization (WMCS018-05)	5	
Software Maintenance & Evolution (WMCS013-05)	5	
Statistical Signal Processing (WMAS011-05)	5	
Systems Engineering (WMIE021-05)	5	
Cloud Computing and Cloud-based Applications (WMCS032-05)	5	
Basic Detection Techniques (WMAS002-05)	5	
Basiscursus Master Lerarenopleiding (TEM0105)	5	
Masterstage 1 (TEM0205)	5	
Astronomical Data Science (WMAS007-05)	5	
<b>Biennial courses, offered in 2023-2024</b>		
Particle Cosmology (WMPH025-05)	5	
<b>Biennial courses, offered in 2024-2025</b>		
Active Galaxies and AGN (WMAS022-05)	5	
Gravitational Waves (WMPH022-05)	5	

For the specialization Data Science & Systems Complexity a maximum of 10 ECTS may be chosen from the option groups in the table above or from the Capita Selecta Courses, listed below. Though no more than three Capita Selecta Courses may be selected.



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## **Appendix V Entry requirements and compulsory order of examinations (art. 4.4)**

For students admitted to the degree programme the conditional entry requirements for individual modules and order of examinations are listed in Ocasys.



## **Appendix VI Admission to the degree programme and different tracks (art. 2.1A.1 + 2.1B.1)**

### **Direct admission**

Graduates with a degree from one of the following degree programmes and universities are considered to have sufficient knowledge and skills and will be admitted to the Master's degree programme in Astronomy on that basis:

- BSc Astronomy, University of Groningen
- BSc Astronomy, Leiden University
- BSc Physics & Astronomy, University of Amsterdam/Vrije Universiteit Amsterdam
- BSc Physics & Astronomy, Radboud University

### **Admissions Office**

Students with a background in a physics or related bachelor's degree programme and interested in pursuing a master's degree programme in Astronomy are encouraged to apply through the Admissions Office of the Faculty of Science and Engineering. The Board of Admissions of Astronomy will then assess the application and decides whether the applicant has sufficient background to register for the programme, possibly after following a bridging pre-master's programme.



## **Appendix VII Transitional provisions (art. 7.1)**

### **8.1 Transitional arrangement 2023-2024**

No transitional arrangements.

### **8.2 Transitional arrangement 2022-2023**

No transitional arrangements.

### **8.3 Transitional arrangement 2021-2022**

No transitional arrangements.

### **8.4 Transitional arrangement 2020-2021**

No transitional arrangements.



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## **Appendix VIII Additional Requirements Open degree Programmes (Art. 3.10)**

Students wishing to pursue an open degree programme may file a request with the Board of Examiners of Astronomy. The Board of Examiners will evaluate whether the proposed curriculum meets the learning outcomes of the degree programme.