Please note that only the German version of the Curriculum is legally binding. All other linguistic versions are provided for information only

Curriculum for the **Erasmus Mundus Joint Master Program in Astrophysics** at the Faculty of Mathematics, Computer Science and Physics of the University of Innsbruck

§ 1 Description of the Erasmus Mundus Joint Master Program in Astrophysics and its organization

(1) This study program is Europe oriented and based on a cooperation between the University of Innsbruck (in the following abbreviated as IBK) as Coordinating Institution (letter of notification 159523-1-2009-1-AT-ERA MUNDUS-EMMC of 15.7.2009), and the Partner Institutions Padua (PD), Rome (Roma), Göttingen (GÖ) und Belgrade (BG). It is a study program within the frame of the Program of Excellence Erasmus Mundus of the European Commission in which high quality education in the field of Astrophysics will be imparted and where especially the complementary expertise of the Partner universities will be utilized.

(2) The international focus of the course of studies involves that all participating students will complete the first semester (S1) at the coordination University in Innsbruck. The second semester (S2) is offered at the University of Padua and the University of Rome and can be completed at one of those two institutions according to the choice of each student. The third semester is provided by the Universities of Rome, Göttingen and Belgrade and can be spent at one of those institutions. The fourth semester (S4) includes the master thesis and the thesis defence (Defensio) and may be completed at each one of the participating institutions depending on the specialization of the student.

(3) For a successful competition the acquisition of at least 120 ECTS credits is required. According to the guidelines of the Erasmus Mundus Call 2009-2013 (EAC/04/2009) and the Program Guide for EMMCs (Action 1A) and the thereof resulting Framework Agreement 2010-0135/001 of 23.11.2009 it is a precondition to gain at least 30 ECTS credits at the University of Innsbruck and at least 60 ECTS credits at participating universities in the EU (or 15 ECTS credits at the University of Belgrade and 45 ECTS credits at participating universities in the EU) in order to successfully complete the Erasmus Mundus Joint Master Program in Astrophysics.

(4) The degree will be awarded together with a joint official certificate.

§ 2 Qualification Profile

(1) The Erasmus Mundus Joint Master Program is assigned to the field of the Studies of Natural Sciences.

(2) With the support of a special program of excellence the international study program of Astrophysics broadens the bachelor studies of Physics with further knowledge and qualifications in order to enable students to carry out highly qualified, independent and innovative research and development projects.

(3) Moreover, students will learn problem solving strategies which will qualify them to gain new knowledge in the research and/or innovative field and to develop new procedures as well as to integrate knowledge of different areas. This will be achieved by deepened studies of chosen prevailing sections together with an international involvement in modern research and increased mobility.

(4) Graduates of this program possess a crucial awareness for questions regarding education and are qualified to act competently and successfully at interfaces between individual research areas but

also between different scientific cultures which is last but not least due to the internationality of the study program.

§ 3 Extent and Duration

The Erasmus Mundus Joint Master Program in Astrophysics comprises 120 ECTS credits; which equals a duration of study of 4 semesters. One ECTS credit equals a workload of about 25 hours.

§ 4 Admission, number of students and selection procedure

(1) A prerequisite for the admission to the Erasmus Mundus Joint Master Program in Astrophysics is a bachelor degree or an equivalent study program from an accredited domestic or foreign educational institution at university level. In case equivalence is in general given and only individual supplements are necessary for complete equivalence the rector's office is entitled to ask for additional exams during the Master Course in order to ascertain the equivalence.

(2) Equivalent studies according to par. 1 are all studies in the field of Physics, Astronomy or Astrophysics whereas equivalence is given in case of study duration of three years respectively 180 ECTS credit points.

(3) According to the Agreement on Cooperation (Framework Agreement 2010-0135/001 of 23.11.2009, Annex I, Part E) the number of students is limited to 40.

(4) The admission of students will be performed by the rector's office. The admission procedure based on the contract to establish the program will be disclosed by the rector's office separately.

§ 5 Language

Studies will be held in English with the exception of the optional modules for language training (§ 8 (2) Z10 and Z11).

§ 6 Courses and maximum number of participants

(1) Lecture (VO): A lecture introduces students in a didactical way to terms, results and methods of the treated area of expertise. The purpose is to arouse interest and impart structured knowledge and a basic understanding of a certain field of activity.

(2) Proseminar (PS): A proseminar is linked closely to a lecture. Students are given examples whose calculations and solutions will be discussed in the proseminar. If it is closely linked with a lecture the contents of the respective lecture will be repeated and practised. Aim: To practise self-reliant problem-solving abilities, to practise methodical work, practise the presentation of technical contents and scientific broadening of taught topics. Exam mode: continuous assessment of course work (compulsory attendance); maximum number of students per group: for compulsory modules 5, for complementary modules 25

(3) Practical training (PR): a practical training should supply students with practical skills through guided but self-dependent work; it supports the practical discussion regarding scientific topics. Exam mode: continuous assessment of course work (compulsory attendance); maximum number of students per group: 10

(4) Seminar (SE): A seminar/tutorial provides the scientific discussion about contents and methods of a certain topic by the use of presentations, papers and discussions. Students should be taught how to write a report (seminar paper) and how to present the topic orally (lecture). Exam mode: continuous assessment of course work (compulsory attendance); maximum number of students per group: 15

§ 7 Procedure for the allocation of places in courses with a limited number of participants

In courses with a limited number of participants places will be allocated as follows:

1. Students for whom a postponement would mean a prolongation of their study period have to be preferred.
2. If criterion Z1 is not sufficient for the regulation of the admission to a course then students have to be preferred if the course is part of the compulsory module and then those students should be admitted for whom the course is part of a optional module.
3. In case criteria Z1 and Z2 are not sufficient for the regulation of the admission to a course the available places will be drawn.

§ 8 Compulsory- and complementary modules

(1) In the first semester (S1) all students of the Erasmus Mundus Joint Master Program in Astrophysics have to successfully complete the following compulsory modules to the extent of 25 ECTS credits:

1.	**Compulsory Module: Concepts of Galactic Astrophysics**	**SSt**	**ECTS credits**
a.	**VO Concepts of Galactic Astrophysics** Hydrodynamics of the stellar interior, stellar evolution and details of the nuclear processes, structure and dynamics of the Galaxy, the Galaxy in the global context, interstellar matter, (extrasolar-)planets	2	3
b.	**PS Concepts of Galactic Astrophysics** Calculus and applications regarding the contents of the lectures.	2	3,5
	Total	**4**	**6,5**
	Learning aim of this module: Attendees of this module should fully understand the contents of the lecture as well as reproduce and apply them. They should have acquired the skill to work out further concepts of galactic astrophysics independently.		
	Requirements for registration: none		

2.	**Compulsory Module: Concepts of Extragalactic Astrophysics**	**SSt**	**ECTS credits**
a.	**VO Concepts of Extragalactic Astrophysics** Galaxies: properties, formation and evolution, active galactic nuclei, groups and clusters of galaxies, cosmology, telescopes	2	3
b.	**PS Concepts of Extragalactic Astrophysics** Calculus and applications regarding the contents of the lectures.	2	3,5
	Total	**4**	**6,5**
	Learning aim of this module: Attendees of this module should fully understand the contents of the lecture as well as reproduce and apply them self-dependently. They should have acquired the skill to work out further concepts of extra-galactic astrophysics and cosmology independently.		
	Requirements for registration: none		

3.	Compulsory Module: Concepts of Physics for Astrophysicists	SSt	ECTS credits
a.	**VO Concepts of Physics for Astrophysicists** radiation processes in astrophysics: fundamentals of radiative transfer, basic theory of radiation fields, radiation from moving charges, relativistic covariance and kinematics, bremsstrahlung, synchrotron radiation, Compton scattering, plasma effects, atomic structure, radiative transitions, molecular structure	2	3
b.	**PS Concepts of Physics for Astrophysicists** Calculus and applications regarding the contents of the lectures.	2	3
	Total	**4**	**6**
	Learning aim of this module: Attendees of this module should fully understand the contents of the lecture as well as reproduce and apply them self-dependently. They master basic techniques in physics within the frame of the common astrophysical overview.		
	Requirements for registration: none		

4.	Compulsory Module: Advanced Mathematical Methods for Astrophysicists	SSt	ECTS credits
a.	**VO Advanced Mathematical Methods for Astrophysicists** Numerical methods and statistics applied to astrophysics problems: theory of distributions, principal component analysis, maximum likelihood method, Bayesian likelihood analysis, Monte Carlo modeling, bootstrap and jackknife, statistical properties of Fourier transforms, filtering, two-point angular correlation function, counts in cells.	2	3
b.	**PS Advanced Mathematical Methods for Astrophysicists** Calculus and applications regarding the contents of the lectures.	2	3
	Total	**4**	**6**
	Learning aim of this module: Attendees of this module master numeric, mathematical and statistical methods and apply those for the solution of problems within astrophysics according to the contents of lectures and are able to use those methods self-dependently.		
	Requirements for registration: none		

(2) Within the first semester (S1) all students of the Erasmus Mundus Joint Master Program in Astrophysics have to attend optional modules to the extent of 5 ECTS credits:

1.	Optional Module: Basic Concepts of Quantum Physics	SSt	ECTS credits
	VO Basic Concepts of Quantum Physics Basic information for the understanding of research relevant topics from the atomic physics, molecular physics, quantum optics and quantum information: Light - matter interaction, coherence effects, interferometry, folding, matter waves, quantum gases, precision measuring, macroscopic quantum phenomena	3	5
	Total	**3**	**5**

	Learning aim of this module: Attendees of this module should fully understand the contents of the lecture as well as reproduce and apply them. They should have acquired the skill to work out further basic concepts of quantum physics self-dependently. Moreover, they should have obtained a basic understanding for the research oriented way of thinking within the field of the quantum physics.
	Requirements for registration: none

2.	Optional Module : Basic Concepts of Ion, Plasma, and Applied Physics	SSt	ECTS credits
	VO Basic Concepts of Ion, Plasma, and Applied Physics Electron / ions - matter interaction, plasmas in nature and technology, behaviors of plasmas, concepts the nuclear fusion and energy physics, molecule physics, mass spectrometry and analysis method, cluster physics and nanotechnology, nonlinear dynamics, bases the electrical engineering	3	5
	Total	**3**	**5**
	Learning aim of this module: Attendees of this module should fully understand the contents of the lecture as well as reproduce and apply them. They should have acquired the skill to work out further basic concepts of Ion, Plasma, and Applied Physics independently. Moreover, they should have obtained a basic understanding for the research oriented way of thinking within the field of Ion, Plasma and Applied Physics.		
	Requirements for registration: none		

3.	Optional Module: Basic Concepts of Astro and Particle Physics	SSt	ECTS credits
	VO Basic Concepts of Astro and Particle Physics Galactic and extragalactic dynamics, cosmology, structure formation and structure development, dark matter/energy, gamma and X-ray astrophysics, relativistic kinematics, electromagnetic, strong and weak elementary processes, Feynman diagrams, hadron systematics, quark hypothesis and chromodynamics, electric weak union	3	5
	Total	**3**	**5**
	Learning aim of this module: Attendees of this module should fully understand the contents of the lecture as well as reproduce and apply them. They should have acquired the skill to work out further basic concepts of Astro and particle physics self-dependently. Moreover, they should have obtained a basic understanding for the research oriented way of thinking within the field of Astro and Particle Physics.		
	Requirements for registration: none		

4.	Optional Module: Relativity	SSt	ECTS credits
	VO Relativity Minkowski geometry, pseudo-Riemann geometry, Einstein equations, Schwarzschild-Kruskal solutions, cosmology (Robertson-Walker solution)	3	5
	Total	**3**	**5**
	Learning aim of this module: Attendees of this module should fully understand the contents of the lecture as well as reproduce and apply them. They should have acquired the skill to work out further topics of the theory of relativity self-dependently.		

	Requirements for registration: none

5.	Optional Module: Astroparticle Physics	SSt	ECTS credits
	VO Astroparticle Physics astrophysical nucleosynthesis, extensive structures, interstellar medium; standard model of the non gravitational forces as a calibrating theory, radiation corrections, experimental tests; cosmic radiation, neutrinos	2	2.5
	Total	**2**	**2.5**
	Learning aim of this module: Attendees of this module should fully understand the contents of the lecture as well as reproduce and apply them. They should have acquired the skill to work out further topics of the astroparticle physics self-dependently. Moreover, they should have obtained a basic understanding of astroparticle physics.		
	Requirements for registration: none		

6.	Optional Module: Special Lectures	SSt	ECTS credits
	VO Special lectures Chosen topics from the astro and particle physics as offered within the Curriculum Master Physics (e.g.: theory of gravitational lenses, variable stars, introduction to radioastronomy, recent results of galactic research, solar and stellar physics, signal processing, physics of dust, physics of star clusters, ..)	2	2.5
	Total	**2**	**2.5**
	Learning aim of this module: Attendees of this module should fully understand the contents of the lecture as well as reproduce and apply them. They should have acquired the skill to work out further topics of the astro and particle physics independently. Moreover, they should have acquired a deepened understanding for chosen topics of Astro and particle physics.		
	Requirements for registration: none		

7.	Optional Module: Statistics and Detectors	SSt	ECTS credits
a.	**VO Statistics and Detectors** Basic statistical tests, mathematical background and requirements, small event number statistics, ideal and real detectors, physics of important detectors and their capabilities, data reduction techniques, analysis and interpretation, faulty and nonlinear qualities of detectors and correction possibilities, analysis of time series data.	2	2.5
b.	**PS Statistics and Detectors** Discussion, consolidation and application of content of lecture; training at a computer	1	2.5
	Summe	**3**	**5**
	Learning aim of this module: Attendees of this module should fully understand the contents of the lecture as well as reproduce and apply them. They should have acquired the skill to work out further contents of statistics and detectors self-dependently. Furthermore, they should have obtained a basic understanding for statistics and detectors.		

	Requirements for registration: none

8.	**Optional Module: Computational Methods in Physics and Astrophysics**	**SSt**	**ECTS credits**
	VO Computational Methods in Physics and Astrophysics Various techniques to simulate fluids, plasmas and N-body systems, applications in several examples of cosmic objects, investigating numerical stability	2	5
	Total	**2**	**5**
	Learning aim of this module: Attendees of this module should fully understand the contents of the lecture as well as reproduce and apply them. They should have acquired the skill to work out further contents of numerical mathematics. Moreover, they should have acquired a basic understanding for numerical mathematics.		
	Requirements for registration: none		

9.	**Optional Module: Astrophysics Seminar (Seminar AT)**	**SSt**	**ECTS credits**
	SE Astrophysics Seminar (Seminar AT) Independent preparation and composition of a talk on a technical or scientific problem. Its content should go beyond the topics covered by the previous studies towards new scientific results.	2	5
	Total	**2**	**5**
	Learning aim of this module: Attendees of this module should fully understand the contents of the lecture as well as reproduce and apply them. They should have acquired the skill to work out independently further contents of the theory of relativity. Attendees of this module should be in a position to deal with problems of the astroparticle physics in a creative and methodically correct way and to present the result of this examination comprehensibly in written and oral form.		
	Requirements for registration: none		

10.	**Optional Module: German as Foreign Language**	**SSt**	**ECTS credits**
	SE German as foreign Language	2	5
	Total	**2**	**5**
	Learning aim of this module: Main features of the use of the German language in everyday life		
	Requirements for registration: none		

11.	**Optional Module: German as Foreign Language - Conversation**	**SSt**	**ECTS credits**
	SE German as foreign Language – conversation	1	2,5
	Total	**1**	**2,5**
	Learning aim of this module: Use of the German language in everyday life		

	Requirements for registration: none

12.	Optional Module: „Gender in Science“	SSt	ECTS credits
	SE Gender in science	1	2,5
	Total	**1**	**2,5**
	Learning aim of this module: Students should possess basic knowledge of gender in science (on the one hand regarding the dimension „women in science“, that is knowledge with respect to scientists for example in the field of physics/astrophysics and on the other hand the dimension „gender in science“, that is knowledge regarding the gender dimension in the culture of science and in the research area). Moreover, they should be aware of relevant equal treatment programs at university level and EU level in the field of „science and research“.		
	Requirements for registration: none		

(3) Modules of the second (S2) and third (S3) semester are to be completed at the partner universities according to § 2 (2). An overview for orientation for the second (S2) and the third (S3) semester can be found as attachment respectively in the corresponding curricula.

(4) Fourth Semester:
If the fourth semester (S4) is spent at the Innsbruck University the master thesis has to be prepared in Innsbruck and also the following compulsory module covering 2,5 ECTS credits.

5.	Compulsory Module: Defense of Master Thesis	SSt	ECTS credits
	Study concluding oral defense of master thesis in front of examination senate.		2,5
	Total		**2,5**
	Learning aim of this module: Reflection of master thesis in the global context of the Erasmus Mundus Joint Master Program in Astrophysics. In the foreground will be theoretical understanding, methodical fundamentals, imparting of results of the master thesis and presentation skills.		
	Requirements for registration: Positive assessment of all other compulsory modules and of the required complementary / optional modules as well as of the master thesis.		

§ 9 Master Thesis

(1) If the master thesis within the Erasmus Mundus Joint Master Program in Astrophysics is written at the Innsbruck University according § 1 (2), it has to amount to 27,5 ECTS credits. The master thesis is a scientific thesis which serves the proof of the qualification to work out a scientific subject independently and with regard to contents and methods in a suitable way.

(2) The subject of the master thesis has to be closely connected with the field of research of astrophysics or astroparticle physics.

(3) The student is entitled to propose the subject of the master thesis or to choose from a number of proposals.

(4) Will the master thesis be written in Innsbruck it has to be compiled in English.

§ 10 Study and examination regulations

(1) All students have to take an exam about the contents of each lecture in a compulsory or optional module. The supervisor of the module will inform the students at the beginning of each course if it will be held in written or oral form.

(2) With respect to seminars successful participation, a lecture and a written seminar thesis will be assessed.

(3) For all other courses with the exam mode “continuous assessment of course work” the assessment criteria will be announced by the supervisor respectively lecturer before starting the course.

(4) Each module will be regarded as successfully completed by a positive assessment.

(5) If the fourth semester (S4) will be passed at the University of Innsbruck according to § 1 (2) the studies are finished by the study concluding defense of the master thesis. 2,5 ECTS credits will be allotted to this final exam. The exam will last for about 60 minutes and starts with a 20-minutes public lecture on the master thesis. Afterwards the possibility of public discussion is given. The exam will be concluded with questions regarding the master thesis from members of the examination senate.

(6) Modules successfully completed at the partner universities will be acknowledged. For courses at the partner universities the respective national legal regulations are valid.

§ 11 Academic degree

(1) All graduates of the Erasmus Mundus Joint Master Program in Astrophysics will be awarded the academic degree of "Master of Science", in short „MSc“.

(2) The award of the academic degree will take place through a joint official document of all partner universities according to § 87 (5), Universitätsgesetz 2002.

§ 12 Coming into force

This curriculum will come into force on October 1st, 2010.

Appendix

Modules of the second (S2), third (S3) and fourth (S4) Semester at the partner universities, in case the last one will be completed at one of the partner universities.

Second Semester (S2) in Padua or Rome

Padua		
S2	**ECTS**	**Type**
Astronomical Spectroscopy	5	Compulsory
Theoretical Astrophysics	5	Compulsory
Cosmology	5	Compulsory
Galaxy Dynamics	5	Compulsory
High Energy Astrophysics	4	Optional/Additional qualification
Astrophysics of Galaxies	5	Optional/Additional qualification
Astrophysics of Interactions	5	Optional/Additional qualification
Formation of Cosmic Structures	5	Optional/Additional qualification
Astrophysics of Interstellar Medium	5	Optional/Additional qualification
Theoretical Astrophysics: Collapsed Stars	5	Optional/Additional qualification
Space Plasma Physics	5	Optional/Additional qualification
Celestial Mechanics	5	Optional/Additional qualification
Stellar Populations	5	Optional/Additional qualification
Italian as a Foreign Language	3	Optional/Additional qualification
Rome		
S2	**ECTS**	**Type**
Observational Solar Physics	6	Compulsory
Stellar Astrophysics	6	Compulsory
Extragalactic Astrophysics 1	6	Compulsory
Relativity and Cosmology 1	6	Compulsory
Choice of courses and activities for 6 ECTS among those listed in table WP below	6	Compulsory
Italian as a foreign language	3	Optional/Additional qualification

Third Semester (S3) in Rome, Göttingen or Belgrade

Rome		
S3	**ECTS**	**Type**
Relativity and Cosmology 2	6	Compulsory
Physics of Gravitation	6	Compulsory
Choice of courses and activities for 18 ECTS among those listed in annex table WP	18	Compulsory
Italian as a foreign language	3	Optional/Additional qualification
Rome: Annex table WP (for S2 and S3)		
Radiative Processes in Astrophysics (S3)	6	Optional/Additional qualification
Astrophysics Laboratory (S3)	6	Optional/Additional qualification
Astronomical Archives (S2)	6	Optional/Additional qualification
High Energy Astrophysics (S3)	6	Optional/Additional qualification
Extragalactic Astrophysics 2 (S2)	6	Optional/Additional qualification
Astrophysics of Galaxies (S3)	6	Optional/Additional qualification
Theoretical Solar Astrophysics (S2)	6	Optional/Additional qualification
Space Physics (S2)	6	Optional/Additional qualification
Celestial Mechanics (S3)	6	Optional/Additional qualification
Gravitational Waves (S3)	6	Optional/Additional qualification
Planetology (S3)	6	Optional/Additional qualification
Astrobiology (S3)	6	Optional/Additional qualification
Stage (S2 or S3)	6	Optional/Additional qualification

Göttingen		
S3	**ECTS**	**Type**
Active Galactic Nuclei	5	Compulsory
Stellar Structure and Evolution	5	Compulsory
Stellar Atmospheres	5	Compulsory
Physics of the Sun, Heliosphere and Space Weather	5	Compulsory
Introduction to Solar System Physics	4	Optional/Additional qualification
Cosmology	4	Optional/Additional qualification
Scientific Computing for High Energy Physics	4	Optional/Additional qualification
Belgrade		
S3	**ECTS**	**Type**
Spectroscopy of Astrophysical Plasmas	6	Compulsory
Physics of Gaseous Nebulae and Active Galactic Nuclei	6	Compulsory
Physics of Interstellar Matter	5	Optional/Additional qualification
Astrobiology	4	Optional/Additional qualification
Line Shapes in Astrophysics	4	Optional/Additional qualification
Introduction to Nucleosynthesis and Particle Astrophysics	5	Optional/Additional qualification
Numerical Astrophysics - Modelling Stellar Atmospheres	5	Optional/Additional qualification
Gravitational Lenses	4	Optional/Additional qualification
Supernovae and Their Remnants	4	Optional/Additional qualification
Serbian as a Foreign Language	5	Optional/Additional qualification

Fourth Semester (S4) in Padua, Rom, Göttingen or Belgrade unless completed in Innsbruck

Padua		
S4	**ECTS**	**Type**
Master Thesis + Presentation	30	Compulsory
Italian as a Foreign Language	3	Optional/Additional qualification
Rome		
S4	**ECTS**	**Type**
Master Thesis + Presentation	30	Compulsory
Göttingen		
S4	**ECTS**	**Type**
Master Thesis + Presentation	30	Compulsory
Astrophysics Seminar	2.5	Optional/Additional qualification
Belgrade		
S4	**ECTS**	**Type**
Master Thesis + presentation	30	Compulsory