

Università degli Studi di Milano-Bicocca

Regolamento didattico

Course of study	F5802Q - ASTROPHYSICS AND SPACE PHYSICS
Type of course	Master Degree
Class	Master's Class: Sciences of the Universe (LM-58)
Year of Approval	2021/2022
Year Regulation (cohorts)	2024/2025

Presentazione

Host Institution	DEPARTMENT OF PHYSICS "GIUSEPPE OCCHIALINI"
Reference Teachers	- SEBASTIANO CANTALUPO
	- MONICA COLPI
	- MASSIMO DOTTI
	- MICHELE FUMAGALLI
	- DAVIDE GEROSA
	- BRUNO GIACOMAZZO
	- FEDERICO NATI
	- ALBERTO SESANA
	- SEBASTIANO CANTALUPO
	- MONICA COLPI
Tutor	- MASSIMO DOTTI
	- MICHELE FUMAGALLI
	- MASSIMO GERVASI
	- ALBERTO SESANA
Duration	- MARIO ZANNONI
	2 years
	120
CFU	
Title Issued	Master's Degree in ASTROPHYSICS AND

	SPACE PHYSICS
Joint Title	No
Double Title	No
Teaching Mode	Conventional
Language/s in which the course is held	English
Internet address of the course	https://www.fisica.unimib.it/it/didattica/corsi-studio#main-content
The course is	Course 509 transformation
Maximum number of credits recognised	12
Courses in the same class	F5801Q - ASTROFISICA E FISICA DELLO SPAZIO
Locations of the course	MILAN (Educational Responsibility)

Article 1. The Course in brief

The Master's Degree in Astrophysics and Space Physics belongs to the Class of Sciences of the Universe (LM-58). The nominal duration of the Master is two years. To obtain the Master's Degree it is necessary to acquire 120 Course Credits (CFU, hereon), of which 72 are earned through final exams and 48 are earned through the writing and editing of a Master's Thesis (45 CFU) of significant research content and novelty. 3 additional CFUs are acquired by exploiting additional educational activities.

The Master's Course is open access: for admission procedures please refer to Article 6 of the Course regulation. The official language is English. All courses are taught in English. At the end of the Master's Course, we release the Master's Degree in Astrophysics and Space Physics.

The Master's Degree provide access to PhD programs and/or advanced-level (Level II) Master's courses offered at the University of Milano-Bicocca, as well as at universities and research centers worldwide. The Master's program offers solid training in fields related to Astrophysics, Physics, and Mathematics. Students are prepared to address the challenges of acquiring and analyzing large sets of astronomical data, interpreting their physical significance, and developing high-tech astronomical instrumentation. Graduates are trained to become scientists at universities and research centers, researchers in industry, schoolteachers, software developers, or experts in science communication.

Article 2. Specific training objectives and description of the training course

The Master's Degree in Astrophysics and Space Physics, in English, is part of the framework for second cycle courses in Universe Sciences. In addition to providing students with insights that expand the knowledge acquired during the first cycle of studies in the physical disciplines, the program offers a solid training in the disciplines that define the LM-58 class. Specifically, graduates of the Master's program acquires skills in modelling complex systems within the fields of astrophysics and space physics and in the use of advanced technological instrumentation and parallel calculation methods. This training enables to collaborate and take direct responsibility for the design and execution of research activities. Proficiency in English are prepared to work to in an international context.

The course is structured to allow the student to choose a training path that emphasizes either observational, experimental, technological or theoretical aspects of the field. However, a common basic training in the field of Astrophysics and Space Physics is also provided. The program includes compulsory

courses aimed at providing fundamental knowledge that is common across various areas of astrophysics (from small to large scale). Additionally, there are compulsory elective courses, both core and related, designed to deepen students' knowledge in specific research fields and to support the preparation of their Master's thesis. The program is completed with free-choice activities, "Further Training Activities," and the final exam.

Specifically, the courses offered fall into three areas:

1. Common Training Area: This area provides courses designed to deepen fundamental knowledge in astrophysics, ensuring a broad common foundation to all students. These courses are cornerstone for the curriculum and cover the essentials of stellar and extragalactic astrophysics, cosmology and relativistic astrophysics and compact objects. Practical sessions focus on the analysis of large quantities of data sets and numerical modelling of complex systems.

2. Area of Specialist Training: This area offers courses aimed at enhancing the observational, theoretical/interpretative and experimental aspects of contemporary astrophysics. In particular, the courses taught provide:

- In-depth knowledge of the data acquisition tools used to detect the different signals (electromagnetic waves, cosmic rays and gravitational waves) contributing to the new multi-messenger astrophysics;
- In-depth knowledge of gravitational wave sources, which are extremely important and relevant for both existing and future space interferometry experiments;
- Insights into topical aspects of contemporary cosmology, including the frontiers of the study of cosmic background radiation and the formation and evolution of large-scale structures.

3. Area of Completion Training: This area provides additional courses in astrophysics and related fields to equip students with transversal skills useful for the thesis work and possible job opportunities. Specifically, this section expands knowledge in advanced Bayesian statistics, including numerical algorithms for parameter space sampling, as well as high performance numerical simulations and parallel computing. The courses of this area cover topics common to astrophysics and gravitation and particle physics.

The teaching methods and tools used to achieve the expected learning outcomes include lectures, exercises, laboratory activities, thesis preparation. The results are verified by interviews, written tests, practical tests and reports on the activities carried out, writing and discussion of the Master's thesis.

Expected learning outcomes are expressed through the Dublin Descriptors:

"Knowledge and understanding" and "Ability to apply knowledge and understanding"
(Summary)

Graduates of the Master's Degree in Astrophysics and Space Physics will have a broad knowledge of advanced topics in astrophysics, cosmology and technologies in the space. They also gain knowledge of methods used in physics, astrophysics and experimental astrophysics. They also acquire mathematical, statistical and computer tools for physics and astrophysics and their applications.

Knowledge and comprehension skills are acquired through lectures, exercises and laboratory work, and evaluated through examinations.

"Ability to apply knowledge and understanding"

Graduates of the Master's program in Astrophysics and Space Physics will be capable of applying the

scientific method to both modeling and investigations in physical and astrophysical domains, as well as in multidisciplinary contexts. They will also be able to use advanced techniques and knowledge to formulate and solve complex problems in astrophysics, space physics, and other fields. These skills are developed through lectures, exercises, laboratory activities, and thesis preparation, and are assessed through exams, thesis writing, and thesis defense.

"Knowledge and understanding" and "Ability to apply knowledge and understanding": Detail:

1. Common Training Area:

“Knowledge and Understanding”

Joint Training for Master’s Degree in Astrophysics and Space Physics:

- i - acquire a broad knowledge of advanced topics in Astrophysics and Cosmology;
- ii. - acquire knowledge of the investigation methods of Physics and Astrophysics;
- iii. - use mathematical, computational and analytical tools in Physics and Astrophysics and apply them effectively.

“Ability to apply knowledge and understanding”

Through the Joint Training, graduated of the Master’s Degree in Astrophysics and Space Physics will be able to apply the scientific method to both modelling and investigation within the aforementioned fields and in multidisciplinary contexts.

Knowledge and skills are acquired and tested in the following training activities:

- Introduction to Cosmology
- Introduction to Galaxies
- Relativistic Astrophysics
- Stellar Astrophysics

2. Area of Specialistic Training:

Knowledge and understanding

The Master’s degree graduate in Astrophysics and Space Physics, through the attendance of specific courses in this area, acquire a comprehensive understanding of the observational, theoretical/interpretative and experimental aspects of contemporary astrophysics.

Ability to apply knowledge and understanding

The Master’s Degree graduate in Astrophysics and Space Physics, through the completion of specific courses in this area, is able to apply techniques and knowledge to formulate and solve in the formulation complex problems in fields of contemporary astrophysics, as well to prepare for the final thesis.

Knowledge and skills are acquired and tested in the following training activities:

- Astronomical Instrumentation
- Astrophysics of Gravitational Waves
- Cosmic Structure Formation
- Dynamics of Stellar Systems

- Experimental Cosmology
- Laboratory of Data Acquisition

3. Completion Training Area:

Knowledge and understanding

The Master's degree graduate in Astrophysics and Space Physics, through the attendance of specific courses in this area, acquire a cross-disciplinary knowledge in fields related to Astrophysics.

Ability to apply knowledge and understanding

Thanks to these courses, the Master's degree graduate in Astrophysics and Space Physics will acquire a good level of understanding and transversal skills in Astrophysics and related fields.

Knowledge and skills are acquired and tested in the following training activities:

- Astrostatistics and Machine Learning
- Cosmic Rays
- General Relativity
- Modern Cosmology and Galaxy Formation
- Numerical Relativity
- Radiative Processes

“Autonomy of judgment “

Master's Degree graduates in Astrophysics and Space Physics acquire:

- Full capacity to broaden and integrate their knowledge in order to make appropriate judgements;
- Ability to use their knowledge and methodologies to make independent critical judgements on scientific problems and systems that can be analyzed using the scientific method;
- Ability to reflect on the ethics of science and the social relevance of Astrophysics and Space Physics.

The ability to integrate knowledge independently is developed through courses that foster autonomous insights on specific topics, including through the consultation of articles in leading scientific journals. This skill is further cultivated during the preparation of the master's thesis, during which the student is encouraged to proceed independently on a subject of particular interest for astrophysics and space physics. The achievement of the ability to integrate knowledge and autonomy of judgement, which also includes reflection on ethical and social responsibilities is assessed during the examinations for the final examination.

“Communication skills”

Master's Degree graduates in Astrophysics and Space Physics possess:

- Ability to communicate judgements and achievements clearly, both in writing and orally, including through audiovisual media;
- Ability to adapt communication style to suit the target audience;
- Ability to communicate, collaborate and develop synergies within a working group;
- Ability to discuss in proper scientific English, enabling the graduate to engage in the international scientific community.

The ability to communicate, interact and develop synergies within a working group is fostered through laboratory sessions, where students are assigned tasks and specific objectives in small groups. The ability to effectively communicate knowledge, achievements, conclusions and underlying rationale is stimulated and assessed in all courses, further developed during the preparation of the Master's thesis and evaluated in the final examination.

“Ability to learn “

Master's degree graduates in Astrophysics and Space Physics acquire

- Ability to target scientific texts and publications;
- Ability to integrate independently, as needed and required, their training and knowledge through the use of advanced scientific texts and publications;
- Ability to continue studies in a PhD or Master's Degree or graduate schools.

The ability to consult scientific texts and publications and to integrate them as needed is developed through courses that stimulate independent insights on specific topics, including research and study of original bibliographic references. The progressive acquisition of these skills is assessed through interviews and tests linked to the examinations. These skills are further developed during the preparation of the Master's thesis, where the graduate is required to expand their knowledge. The final examination also serves to verify the acquisition of these skills.

Article 3. Job profiles and employment opportunities

Astrophysicists - Astronomers

3.1 Functions

The Master's degree graduate in Astrophysics and Space Physics is capable of performing tasks such as data collection and analysis, design, implementation and characterization of technological instrumentation, development of theoretical models, both analytical and numerical, for simulating complex systems. Graduated can work in public and private research institutions and/or companies that require these skills.

3.2 Skills

The teaching activities provided by the Master's Degree in Astrophysics and Space Physics provide adequate theoretical and experimental skills to enable graduate students to:

- Develop high-level scientific research, including proposals and coordination tasks;
- Promote and advance scientific and technological innovation, as well as design and manage technologies in fields related to physical and astrophysical disciplines in industrial sectors;
- Transfer knowledge and technological know-how developed through basic research to the economic and production system;
- Develop and use complex reality systems in fields other than science.

3.3 Professional outlets

The Master's degree graduate in Astrophysics and Space Physics will have the necessary skills to work:

- As coordinator or member of research teams at universities, public and private research institutions;
- High-impact industries, particularly space, optics, microelectronics, telecommunications and data processing;

- As developer and modeler of financial models at banks, finance firms, consultancy firms;
- As high-level disseminator of scientific culture with particular reference to the different theoretical, experimental and applied aspects of classical and modern physics, astrophysics and cosmology.

The course prepares for the professions of:

Class: 2.1.1 - Specialists in mathematical, computer science, chemistry, physics and natural sciences
Category: 2.1.1.1 - Physicists and astronomers

Professional unit: 2.1.1.1.1 - Physics

Class: 2.1.1 - Specialists in mathematical, computer science, chemistry, physics and natural sciences
Category: 2.1.1.1 - Physicists and astronomers

Professional unit: 2.1.1.1.2 - Astronomers and astrophysicists

Class: 2.6.2 - University graduates researchers and technicians

Category: 2.6.2.1 - Researchers and technicians graduated in the mathematical, information, physical, chemical, earth sciences

Professional unit: 2.6.2.1.2 - Researchers and technicians with a degree in physical sciences

Article 4. Rules on access

To be admitted to the Master's Degree in Astrophysics and Space Physics, applicants must have a Bachelor's degree or three-year university diploma, or an equivalent qualification obtained abroad.

Basic knowledge is required in the areas of mathematics (including differential calculus, analytical mechanics and geometry), classical physics (both theoretical and experimental), and quantum mechanics.

The degree in class L-30 meets the curriculum requirement.

Students from other degree classes must have at least 18 ECTS in the scientific-disciplinary areas MAT/01-MAT/09 and at least 18 ECTS in the scientific-disciplinary areas FIS/01-FIS/08.

An English language proficiency level of not less than B2 is also required to be admitted.

Article 5. Admission procedure

Verified curricular requirements (degree in class L-30 or at least 18 ECTS in the scientific disciplinary areas MAT/01-MAT/09 and at least 18 ECTS in the scientific-disciplinary sectors FIS/01-FIS/08 or equivalent qualification for students with foreign degrees), admission to the Master's Degree in Astrophysics and Space Physics is subject to an assessment of the applicant's academic preparation, which will be conducted through an interview with a special commission.

The commission will evaluate the required knowledge and recommend an appropriate study path for students to successfully pursue their studies. If the candidate's curriculum does not demonstrate adequate preparation in Quantum Mechanics, which can also be acquired through individual courses and exams, this will be assessed during the interview.

Candidates holding a degree in Physics, Astrophysics or Astronomy (class L-30) with a final grade equal to or greater than 82/110 are exempted from the admission interview. Candidates with an equivalent

foreign degree, i.e. BSc (or equivalent three-year study diploma) in Physics, Astrophysics or Astronomy, with a final grade equal to or higher than a G.P.A. of 3 out of 4 (or equivalent) are equally exempt from the admission interview subject to possession of all curricular requirements.

The deadlines and procedures for submitting the application for qualification assessment, as well as the dates and modalities for conducting interviews and any written examinations, will be published on the website of the Course, at <https://elearning.unimib.it/course/view.php?id=39343&lang=en>

For applicants living more than 100 km from the University or those who are temporarily engaged in documented work, study activities or for health reasons, the commission may, upon request, allow the interview to be conducted via teleconference.

For admission to the course, a minimum English language proficiency level of B2 is required. This requirement is considered fulfilled if the applicant:

- a) Holds a certificate, recognized by the University, issued by an accredited body, corresponding to level B2;
- b) Has passed, within the framework of his previous university career, an examination of at least 4 CFU belonging to one of the Scientific-Disciplinary Sectors between L-LIN/10, L-LIN/11, L-LIN/12
- c) Has obtained the open badge Bbetween English B2 of the University of Milan - Bicocca;
- d) Has a degree which is wholly or mainly in English.

As an alternative to full-time enrolment, the student may enrol part-time in accordance with the procedures defined in art. 12 of the Student Rules.

Article 6. Organization of the course

The Master's Degree in Astrophysics and Space Physics is consists of a first year focused on concentrated teaching, and a second year primarily dedicated to the thesis. The Master's program has a single curriculum, and the training course is organized in lthe following components: Characteristic training activities, for a total of 48 CFU; Related or complementary training activities, for a total of 12 CFU; Other activities, for a total of 60 CFU.

All courses are taught in English.

6.1 - Structure of training activities I Year

- 60 total units

Compulsory courses (30 ECTS):

- Stellar Astrophysics, FIS/05 - 8 CFU (observational-experimental field)
- Relativistic Astrophysics, FIS/05 - 8 CFU (Theoretical-Astronomical Field)
- Introduction to Cosmology, FIS/05 - 6 CFU (Theoretical-Astronomical Field)
- Introduction to Galaxies, FIS/05 - 8 CFU (observational-experimental field)

Three compulsory courses to be chosen from among the following (18 ECTS):

- Laboratory of Data Acquisition, FIS/05 - 6 CFU (astronomical - technological field)
- Cosmic Structure Formation, FIS/05 - 6 CFU (astronomical - technological)
- Dynamics of Stellar Systems, FIS/05 - 6 CFU (astronomical - technological)

- Astrophysics of Gravitational Waves, FIS/05 - 6 CFU (astronomical - technological)
- Experimental Cosmology, FIS/05 - 6 CFU (astronomical - technological)
- Astronomical Instrumentation, FIS/05 - 6 CFU (astronomy - technological field)

The student will also have to acquire 12 ECTS, chosen from the following related or complementary courses:

- Radiative Processes, FIS/05 - 6 CFU
- Modern Cosmology and Galaxy Formation, FIS/05 - 6 CFU
- Cosmic Rays, FIS/01 - 6 CFU
- Astrostatistics and Machine Learning, FIS/05 - 6 CFU
- Numerical Relativity, FIS/02 - 6 CFU
 - General Relativity, FIS/02 - 6

CFU II Year - 60 CFU total

Compulsory activities:

Activities of the student's own choice - 12 ECTS;

Further learning activities - 3 CFU (see art. 6.5);

Master thesis - 45 CFU.

6.2 – Core activities

The courses are aimed at transmitting fundamental knowledge in astrophysics and to deepening the observational, theoretical and experimental aspects of contemporary astrophysics. The topics covered in these activities range from stellar and galaxy astrophysics to cosmology, from compact object astrophysics to data collection and analysis.

6.3 - Related or complementary activities

In the related or complementary training activities are included optional activities that involve further in depth study in the disciplines of astrophysics, experimental and theoretical physics or which are otherwise aimed at ensuring the student an interdisciplinary training and constantly updated.

- Training activities of the student's choice

12 CFU are reserved for training activities of the student's choice. According to the provisions of D.M. 16- 03-2007 - art.3, the student will be able to choose the 12 CFU among all the courses activated in the master's degree courses of the University as long as they are consistent with the training path. Consistency refers to the individual study plan submitted and will therefore be assessed by the Study Plans Committee. According to the current legislation, for the purpose of counting the total number of examinations, the student's elective activities count as one examination.

6.4 - Further training activities

The acquisition of 3 CFU related to "Further training activities" takes place according to the modalities specified below.

ITALIAN students can choose from:

- 3 CFU of other useful knowledge for the world of work, with participation in activities planned in Ateneo for the project I-Bicocca (I-Bicocca Silver, 1 CFU, I-Bicocca Gold, 2 CFU, I-Bicocca Platinum, 3 CFU)

or

- 3 ECTS of additional language knowledge, with the passing of a test of University of English for foreign language skills, level B2, choice between French, Spanish or German, or by passing a C1 level English language proficiency test.

Italian students already in possession of certificates issued by the University or by bodies accredited by the University, attesting language knowledge, at a level equal to or higher than B2 for the languages French, Spanish or German, or attesting language knowledge, level equal to or higher than C1 for the English language, will be entitled to exemption from proof and recognition of credits provided.

FOREIGN students must necessarily achieve 3 CFU of additional language knowledge, with the passing of a test of University of Italian language proficiency, level A2.

Foreign students already in possession of certificates issued by the University or accredited institutions, attesting language knowledge, equal to or above level A2, will be entitled to exemption from proof and recognition of credits provided.

Information on how to conduct the tests or earn credits is defined at the level of the University and will be available on the website of the University, at <https://www.unimib.it/didattica/lingue-unimib>.

6.5 - Stage

The traineeships are included in the final test preparation activities.

6.6 - Forms of education

The teaching activities include lectures, classroom and laboratory exercises, and supplementary seminar activities in which teachers delve deeper into certain topics covered in the frontal teaching. The student's acquisition of knowledge and skills is measured in university training credits (CFU). 1 CFU corresponds to an average of 25 hours of student workload, which includes both the training activities implemented by the Master's Degree and the time allocated for personal study or other individual training activities.

To earn one CFU, the student is expected to engage in 7 hours of lectures, or 8-12 hours of exercises, or 8-12 hours of laboratory work. Credits for each training activity are awarded after passing the exam or through other forms of assessment of the knowledge and skills acquired.

6.7 - Method of profit verification

The examinations may be written and/or oral. Laboratory lessons may also include practical tests. The final assessment will in any case involve an interview. The assessment for traineeship activities involves a short written report and presentation to a panel of lecturers.

Details on how each individual lessons are assessed and evaluated in the course plan can be found on the e-learning site of the Course of Study, under LESSONS <https://elearning.unimib.it/course/index.php?categoryid=7449>

6.8 - Frequency

Attendance is mandatory for laboratory activities (at least 75%) and strongly recommended for other educational activities.

6.9 - Study plan

The study plan consists of a combination of compulsory training activities, optional activities planned and those chosen independently by the student, in accordance with the Regulation and the Teaching Guidelines of the course. It is possible to submit an individual study plan that includes additional training activities beyond those outlines in the Teaching Regulations, provided these activities align with the course's curriculum (teaching order) for the academic year of registration.

The student is assigned a study plan at the time of enrollment in the first year, which constitutes the

statutory study plan. The student must then submit his or her study plan which indicates the activities they may choose. The study plan is approved by the Educational Coordination Council. The University defines the terms and deadlines for submitting the plan. A student's eligibility to take an exam for any activity is contingent on that activity being included in the most recent approved study plan. For further details, please refer to the University Regulations for students.

6.10 - Prerequisites/barriers

No propaedeutic teaching is provided. Students are advised to ensure they meet the prerequisites required by each course, as outlined in the syllabus for each activity. The syllabi are available at the course address <https://elearning.unimib.it/course/index.php?categoryid=7450>.

6.11 - Scanning of training activities and calls for examination

The characterizing and complementary courses which contribute to the training activities are scheduled in the first year and organized across two semesters. The second year is devoted to the remaining training activities and preparation for the final examination.

Examination sessions are normally held during periods when teaching is suspended. For each course, the examination calls must adhere the guidelines set forth by the University's Teaching Rules.

6.12 - International student mobility agreements

The Master's Degree program encourages students to take advantage of periods of training abroad by participating in various international mobility programs, within which bilateral agreements are in place with several prestigious foreign universities.

The "Erasmus+ for study purposes" program allows students to study at a foreign university for a period ranging from a minimum of 3 months to a maximum of one year. During this time, students can take courses and examinations that will be recognized as part of the study plan for the Master's Degree.

The "Erasmus+ for traineeships" program offers opportunities for training and internship activities, including thesis preparation, at EU companies, both private and public, as well as university and non-university laboratories.

The "Extra-EU Exchange" program provides training and internships at both private and public extra-EU companies; training and internships in university and non-university laboratories; thesis preparation in co-supervision at higher education institutions, research centres and NGOs outside the EU.

The Master's Degree program includes a Commission dedicated to international student mobility (Internationalization Commission). The Commission is responsible for developing the international aspects of the course and assisting students in international mobility programs.

During the internship/thesis activity abroad, the student will be guided by a course lecturer who will serve internal supervisor. This supervisor will regularly monitor the student's work and progress, and offer guidance throughout the experience.

The foreign universities affiliated with the Department of Physics are available at the following link: <https://www.unimib.it/internationalizzazione/erasmus-studio/selezioni-erasmus-studio>, under the heading "Destinations for mobility".

The participation modalities and deadlines of the various programs are indicated in the calls published on the University website: <https://www.unimib.it/internationalizze/mobilita-internazionale>.

6.13 - Part-time enrolment

The Master's Degree program requires part-time registration according to the procedures defined in art.12 of the Student Rules of the University of Milano - Bicocca (https://www.unimib.it/sites/default/files/2023-11/reg-stud_Versione%20site.pdf). The aim is to ensure that students who cannot attend courses on a continuous basis can extend their training for up to twice the normal duration of the course. According to the above-mentioned Regulation, the number of credits that can be earned will not exceed what is indicated for each academic year, even if there are validations, recognitions or examinations not taken in previous years.

The part-time course is divided into four years, as follows: I YEAR - 30 total credits

- Stellar Astrophysics - 8 CFU
- Relativistic Astrophysics - 8 CFU
- Introduction to Cosmology - 6 CFU
- Introduction to Galaxies - 8 CFU

I YEAR BIS - 24 CFU total

- Two courses to choose from (12 ECTS - field of technological astronomy):

Laboratory of Data Acquisition, Cosmic Structure Formation, Astrophysics of Gravitational Waves, Experimental Cosmology, Astronomical Instrumentation, Dynamics of Stellar Systems.

- Two courses (12 ECTS - of a similar type to the integrative course) to be chosen from:

Radiative Processes, Modern Cosmology and Galaxy Formation, Cosmic Rays, Astrostatistics and Machine Learning, Numerical Relativity, General Relativity.

II YEAR - 21 CFU total

- Courses at choice 6 CFU: Laboratory of Data Acquisition, Cosmic Structure Formation, Astrophysics of Gravitational Waves, Experimental Cosmology, Astronomical Instrumentation, Dynamics of Stellar Systems.
- Courses of the student's choice - 12 CFU
- Further learning activities - 3 CFU (see Art. 6.5)

II YEAR BIS - 45 CFU total

- Master's thesis, 45 CFU

Details on how each individual teaching is checked and evaluated in the course plan can be found on the e-learning site of the Course of Study under LESSONS <https://elearning.unimib.it/course/index.php?categoryid=7449>

Article 7. Final test

Master's Thesis in Astrophysics and Space Physics (45 CFU)

Master's Thesis Preparation

The preparation of the Master's thesis is a fundamental part of the academic journey. During this period, the student completes their training by applying the acquired skills and is guided by a faculty advisor in a research project on a topic of particular interest and relevance to astrophysics and cosmology, including theoretical, interpretative, and technological aspects. Alternatively, the research may focus on topics related to the history or teaching of astrophysics.

The Master's thesis preparation may include the possibility of a research period at companies or research institutions in Italy or abroad. In any case, the student is assigned supervisors—a primary advisor and a co-advisor—who guide the research process. The thesis work is completed with the preparation of an original dissertation in English and its public defense.

Article 8. Final Examination Procedures

The preparation of the Master's thesis is a key component of the academic journey. During this period, the student consolidates their training by applying the skills they have acquired, under the guidance of a faculty advisor, through a research project focused on a topic of particular interest and relevance to astrophysics and cosmology, including theoretical, interpretative, and technological aspects. Alternatively, the research may explore subjects related to the history or teaching of astrophysics. The Master's thesis may also include the opportunity for a research period at companies or research institutions, either in Italy or abroad. In any case, the student is assigned two supervisors—a primary advisor and a co-advisor—who oversee and guide the research process. The thesis concludes with the preparation of an original dissertation in English, followed by its public defense.

To be eligible for the final examination, the student must have earned at least a minimum 75 ECTS credits (CFU).

The final examination consists of a thesis developed independently by the student under the guidance of an advisor. The thesis will be defended before a committee appointed by the President of the School of Science. The thesis must be written in English, and the defense will also be conducted in English. The final Master's degree grade, awarded on a scale of 110, will be based on the student's academic record and the evaluations of the advisor and the committee, according to the criteria established by the Teaching Coordination Council of Physics and Astrophysics.

Article 9. Recognition of ECTS Credits and Transfer Procedures

In the case of a transfer from another university, the recognition of previously completed exams will be carried out by a designated committee appointed by the Teaching Coordination Council. The recognition will be based on the alignment between the contents of the previous course and the Master's program. Partial recognition of a course is permitted.

Recognition of Professional Activities

According to D.M. 270/2004 and L. 240/2010, universities may recognize professional knowledge and skills certified individually under the applicable regulations, as university credits. Additionally, other knowledge and skills acquired in post-secondary training activities in which the university has been involved in the design and implementation may be recognized for a maximum of 12 ECTS credits, including both undergraduate and graduate courses.

Article 10. Research Activities Supporting the Course's Educational Profile

At the **Departments of Physics "G. Occhialini"** and **Materials Science**, research activities supporting educational training are conducted in the following fields:

- Theoretical Physics
- Fundamental Interaction Physics
- Biophysics
- Solid-State Physics and Material Structure
- Plasma Physics

- Electronics
- Applied Physics for Environment and Medicine
- Quantum Technologies
- Astrophysics and Space Physics

In particular, the astrophysics research group carries out cutting-edge studies in the following areas:

- Formation and cosmic evolution of galaxies and large-scale structures
- Dynamic evolution and accretion processes in compact objects
- Modeling of gravitational wave sources
- Study of cosmic microwave background radiation and the early universe
- Observation and propagation of cosmic rays in space

Article 11. Faculty Members of the Degree Program

Professors teaching in the program:

CANTALUPO Sebastiano-FIS/05
 COLPI Monica-FIS/05
 DOTTI Massimo-FIS/05
 FOSSATI Matteo-FIS/05
 FUMAGALLI Michele-FIS/05
 GEROSA Davide-FIS/05
 GERVASI Massimo-FIS/01
 GIACOMAZZO Bruno-FIS/02
 MADAU Piergiorgio-FIS/05
 NATI Federico-FIS/05
 PIZZUTI Lorenzo-FIS/05
 SESANA Alberto-FIS/05
 TOMASIELLO Alessandro-FIS/02
 ZANNONI Mario-FIS/05

Article 12. Additional Information

Course Location: Department of Physics, Piazza della Scienza 3, 20126 Milan, Italy

- **President of the Teaching Coordination Council for Physics and Astrophysics:** Prof. Maddalena Collini
- **Course Academic Coordinator:** Prof. Sebastiano Cantalupo
- **Program Advisor:** Prof. Monica Colpi
- **President of the Teaching Committee:** Prof. Claudia Riccardi

Teaching Secretariat:

- **Phone:** +39 02 6448 4080
- **Email:** didattica.fisica@unimib.it

Official Course Website:

<https://elearning.unimib.it/course/index.php?categoryid=7449>

For university deadlines and procedures related to enrollment, transfers, and study plan submissions, please refer to the official university website: www.unimib.it.

Non-substantial changes to this academic regulation may occur. In particular, the activation of elective courses will depend on the number of students enrolled. The following section contains tables detailing the

distribution of educational activities by type, subject area, and scientific-disciplinary sector, as well as the breakdown of courses by academic year.

Class/Study Path

- **Class:** Master's Degree Class in Universe Sciences (LM-58)
- **Study Path:** Common Path

Framework of teaching activities

Characterizing				
Disciplinary Area	CFU	Range of CFU per RAD	SSD	Teaching Activities
Astronomical-Observational Experimental	16	8 - 24	FIS/05	F5802Q002M - STELLAR ASTROPHYSICS, 8 CFU F5802Q024 - INTRODUCTION TO GALAXIES, 8 CFU
Astronomical-Theoretical	14	8 - 24	FIS/05	F5802Q003M - RELATIVISTIC ASTROPHYSICS, 8 CFU F5802Q004M - INTRODUCTION TO COSMOLOGY, 6 CFU
Astronomical-Technological	18	8 - 24	FIS/05	F5802Q006M - LABORATORY OF DATA ACQUISITION, 6 CFU F5802Q007M - COSMIC STRUCTURE FORMATION, 6 CFU F5802Q008M - ASTROPHYSICS OF GRAVITATIONAL WAVES, 6 CFU F5802Q009M - EXPERIMENTAL COSMOLOGY, 6 CFU F5802Q010M - ASTRONOMICAL INSTRUMENTATION, 6 CFU F5802Q023 - DYNAMICS OF STELLAR SYSTEMS, 6 CFU
Total Core Subjects	48	24 - 72		
Related/Integrative				
Disciplinary Area	CFU	Range of CFU per RAD	SSD	Teaching Activities
Related or Integrative Educational Activities	12	12 - 24	FIS/01	F5802Q013M - COSMIC RAYS, 6 CFU

			FIS/02	F5802Q015M - NUMERICAL RELATIVITY, 6 CFU F5802Q025 - GENERAL RELATIVITY, 6 CFU
			FIS/05	F5802Q011M - RADIATIVE PROCESSES, 6 CFU F5802Q016M - ASTROSTATISTICS AND MACHINE LEARNING, 6 CFU F5802Q018M - MODERN COSMOLOGY AND GALAXY FORMATION, 6 CFU
Total related/integrative subjcts	12	12 - 24		
Student's selection				
Disciplinary Area	CFU	Range of CFU per RAD	SSD	Teaching Activities
Student-Selected Activities	12	8 - 12	NN	F5802Q300 - CHOSEN ACTIVITIES TAKEN DURING THE ERASMUS PERIOD - 12 CFU, 12 CFU F5802Q302 - CHOSEN ACTIVITIES TAKEN DURING THE ERASMUS PERIOD - 6 CFU, 6 CFU
Total Student-Selected Activities	12	8 - 12		
Language/Final Test				
Disciplinary Area	CFU	Range of CFU per RAD	SSD	Teaching Activities
Dissertation	45	42 - 48	PROFIN_S	F5802Q016 - MASTER THESIS, 45 CFU
Totale dissertation	45	42 - 48		
Other				
Disciplinary Area	CFU	Range of CFU per RAD	SSD	Teaching Activities
Further Linguistic Knowledge	3	0 - 3	NN	F5802Q017 - FURTHER LINGUISTIC KNOWLEDGE, 3 CFU
Other Skills Useful for Employment	3	0 - 3	NN	F5802Q019 - FURTHER SKILLS FOR JOB PLACEMENT, 3 CFU
Total Other	3	0 - 6		
Total	120	86 - 162		

