Università di Bologna

Dipartimento di Fisica e Astronomia ‘Augusto Righi’

Master Degree in Astrophysics and Cosmology

(LM-58 class: Universe Science)

https://corsi.unibo.it/2cycle/Astrophysics/

A.A. 2024-2025

Coordinator: Prof. Cristian Vignali

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General presentation

The Master Degree in Astrophysics and Cosmology

- is a 2-yr long Master Degree program belonging to the Master class of “Science of the Universe”, almost unique in Italy;

- is aimed at studying the physics and evolutionary history of the Universe and cosmic structures;

- is organized in 12 courses (7 compulsory + 5 elective) and a final exam (discussion of the Master Thesis project);

- includes a final project (the Master Thesis) generally consisting of original research on a specific topic in Astrophysics and Cosmology, chosen by the student

Good reasons for being here

- you will have the opportunity to carry-out your own Master Thesis project in one (of the four!) international astrophysical institutes located in Bologna;

- you will acquire a deep knowledge of the most recent developments in the astrophysical and cosmological research, becoming familiar with the physical processes driving the formation and evolution of cosmic objects;

- you will have the opportunity to access some of the most advanced labs for research and instrumentation development in astrophysics;

- you will acquire a full view of the Universe at all electromagnetic wavelengths (radio, infrared, optical, UV, X-rays, very high energies, etc.);

- more than 90% of our students are fully satisfied by our Master Degree course and most of them found a PhD or a job soon after graduation.

Why in Bologna?

- Bologna is one of the main (and most ancient) centres for astrophysics in the world
- Bologna counts 4 different research institutes working together in close synergy:
  - the University department **DIFA**;
  - 2 research institutes belonging to the Italian National Institute for Astrophysics (**INAF**): the Observatory of Astrophysics and Space Sciences (**OAS**) and the Institute for Radioastronomy (**IRA**);
  - the international headquarters of the Cerenkov Telescope Array (**CTA**).
- Bologna offers the entire educational path in astrophysics:
  - a First Degree Cycle (Bachelor) in Astronomy;
  - a Master Degree Cycle in Astrophysics and Cosmology;
  - a PhD program in Astrophysics.
- Bologna thus offers a rich and stimulating international environment for the study of and the professional research in all the main fields of modern astrophysics and cosmology (multi-wavelength observational data, models, simulations, instrumentation, etc.)

Astrophysics in Bologna now

- About 35 professors at UNIBO, members of the Department of Physics and Astronomy (DIFA) “Augusto Righi”

- $\gtrsim$ 90 researchers of the Italian National Institute for Astrophysics (INAF) in two different istitutes (OAS, IRA), all of them now in the Navile campus plus the headquarters of the Cherenkov Telescope Array Observatory (CTAO)

- About 40-50 PhD students (three years)

- $\gtrsim$ 40 postdocs/contracts/etc.

Astrophysics in Bologna

The Navile Campus

Master thesis: original research, variety of topics

- Structure and evolution of stars
- Structure, dynamics, formation and evolution of galaxies
- Active Galactic Nuclei
- Radioastronomy
- Theoretical and observational Cosmology
- Exoplanets
- Astrophysical Instrumentations
- […]

Program of the courses

- The physical processes underlying the formation, evolution and radiative emission of cosmic structures and the Universe, from both a theoretical and observational point of view
- The techniques, both observational and numerical, used by professional astrophysicists to interpret observational data and build interpretative and/or predictive models
- Consolidated knowledge and still open questions in modern astrophysical and cosmological research

FIRST YEAR
STELLAR DYNAMICS
STELLAR EVOLUTION
GALAXY FORMATION AND EVOLUTION
ACTIVE GALACTIC NUCLEI AND SUPERMASSIVE BLACK HOLES
COSMOLOGY
COMPUTATIONAL ASTROPHYSICS AND STATISTICS
(from 1 to 3) ELECTIVE COURSES

SECOND YEAR
MULTI-WAVELENGTH ASTROPHYSICS LABORATORY
PROFESSIONAL SKILLS/INTERNSHIP
(from 2 to 4) ELECTIVE COURSES
MASTER THESIS PROJECT

Total: 5 elective courses

Study plan: compulsory and free-choice/elective courses

5828 – ASTROPHYSICS AND COSMOLOGY (LM58) Bologna		**credits**	
First year	SSD	CFU	Teacher
Active Galactic Nuclei and Supermassive Black Holes	FIS/05	6	C. Vignali
Stellar Dynamics	FIS/05	6	L. Ciotti
Stellar Evolution	FIS/05	8	F.R. Ferraro
Galaxy formation and evolution	FIS/05	8	A. Cimatti
Computational Astrophysics and Statistics	FIS/05	8	F. Brighenti/ R.B. Meltcalf
Cosmology	FIS/05	8	L. Moscardini
Elective course		6	
Free choice learning activities		12	

Second year	SSD	CFU	Teacher
Multiwavelength Astrophysics Laboratory	FIS/05	8	C. Vignali
Professional skill/internship		3	C. Vignali
Elective courses		12	
Preparation and final examination		15+20	

II semester 'free' for the master thesis preparation

Total: 120 CFU (credits)

Elective courses

First semester

Second semester

96388 ADVANCED COSMOLOGY	1	C	FIS/05	6
96390 ASTRONOMICAL INSTRUMENTATION	1	C	FIS/05	6
96391 ASTROPHYSICS OF GALAXIES	1	C	FIS/05	6
B2138 EXOPLANETS: FORMATION, POPULATIONS, AND ATMOSPHERES	1	C	FIS/05	6
96392 GRAVITATIONAL LENSING	1	C	FIS/05	6
B1017 GRAVITATIONAL WAVE ASTROPHYSICS AND COSMOLOGY	1	C	FIS/05	6
77956 SPACECRAFT SUBSYSTEMS AND SPACE MISSION DESIGN	1	C	ING-IND/05	6
96398 THE INTERSTELLAR MEDIUM	1	C	FIS/05	6
96389 Advanced Stellar Physics and Asteroseismology	2	C	FIS/05	6
87966 Astroparticle Physics	2	C	FIS/05	6
94230 Astrophysical Fluid Dynamics	2	C	FIS/05	6
96454 Galaxy Clusters	2	C	FIS/05	6
96393 High Energy Astrophysics	2	C	FIS/05	6
90569 High performance computing for Astrophysics and Cosmology	2	C	FIS/05	6
96394 Magnetic Fields in Astrophysics	2	C	FIS/05	6
86840 Practical Statistics for Physics and Astrophysics	2	C	FIS/05	6
96395 Radioastronomy	2	C	FIS/05	6
96397 Relativity	2	C	FIS/02	6
96396 Resolved Stellar Populations	2	C	FIS/05	6

Free-choice vs. elective courses

- **Free-choice courses** (12-50 cfu): any optional course at the University of Bologna
- **Elective** (‘**group of choice**’) **courses** (6+12 cfu): optional courses to be chosen from the list of 19 offered by our Master (list on the left)

Preparing the study plan

In the period October/December and in March you can decide the elective courses you want to include in your plan for the current academic year. In the second year you can add other courses and/or change some of your choices

Contents of the elective courses will be presented in mid October

A few additional notes

- SPACECRAFT SUBSYSTEMS AND SPACE MISSION DESIGN

offered only online for Astrophysics and Cosmology

- ASTRONOMICAL INSTRUMENTATION

starting this year, students are supposed to take high-energy and micro-wave measurements in a lab at INAF-OAS, so they need also safety module 3. Check dates and instructions on the webpage:
https://corsi.unibo.it/2cycle/Astrophysics/health-and-safety-mandatory-training

Elective courses

Students should be careful about

- In the first semester of the first academic year, students are supposed to attend the mandatory courses only
- Elective (free-choice/group of choice) courses are supposed to be attended by students starting from the second semester of the first year
- The second semester of the second year is supposed to be dedicated to the preparation of the master thesis (if students have already carried out most of their exams)
- Overall suggestion: compulsory courses at first, then the others…

Example: Advanced Cosmology is offered in the first semester → students interested in the subject are kindly suggested to attend it in the first semester of the second year
Another example: Astroparticle Physics is offered in the second semester → students interested in the subject are kindly suggested to attend it in the second semester of the first year

- Finally: free-choice and group of choice courses have different TAF (Tipologia Attività Formative) …

On the synergies among institutes in Bologna

One example:

Multiwavelength Astrophysics Laboratory (8 cfu, II year, I semester)
Hands-on session and research stages carried out in strict collaboration with the two INAF institutes in Bologna:

- Astrophysics and Space Science Observatory (OAS)
- Institute of Radioastronomy (IRA)

- This lab course comprises data analysis of stars, galaxies, and Active Galactic Nuclei, acquisition of expertise in the optical, radio, millimeter, X-rays, and very high energies

Final examination

35 CFU, divided as follows:

- Preparation/internship in Italy/abroad: **15 CFU**
- Discussion: **20 CFU**

Projects:
List of projects on the individual webpages, presented by professors during their courses, and in a special Thesis Day (about January/February each year)

Duration of the activity:
Typically, starting from the second semester of the second year, duration of about 6−9 months
Possibilities to do thesis activities (scientific topics) abroad (two calls per year for grants: Oct/Nov, March/April, stay tuned!)

Sessions:
5 sessions every academic year: July, September, October (last possibility to be enrolled in the PhD program in Bologna), December, March (deadline for taxes)

Final mark (maximum mark 110/110 cum laude):
The Committee will use the **weighted average** of the marks obtained during the two years, then it will add some points taking into account (a) the evaluation of the supervisor, (b) the evaluation of the thesis' referee, and (c) the final public discussion

Organization of the lectures

Lectures are organized in 2 periods (semesters)

SEPT **DEC** **FEB** **MAY**

FIRST YEAR

- Stellar evolution
- Stellar dynamics
- AGN and SMBH
- Galaxy Formation and evolution
- Computational Astrophysics and Statistics
- Cosmology
- **1-3 elective courses**

SEPT **DEC** **FEB** **MAY**

SECOND YEAR

- Multiwavelength Astrophysics Lab.
- **2-4 elective courses**
- Professional skills
- Master Thesis

Exams session

Exam sessions are organized in 3 periods

Each course will offer at least 6 possible dates for the exams

No exams out of the sessions (unless students are ’fuori corso’, i.e., after the second year)

Attending the lectures

Attending the lectures is not compulsory but **strongly** recommended. The same for the courses with laboratory activities

We are aware of possible problems related to delays with visas; however, **all teaching activities** (lectures, labs, exams, …) will be **in presence only** (no remote attendance)

Additional materials related to the courses posted by the teachers can be found in the corresponding pages on VIRTUALE (virtuale.unibo.it). Please register!

Bologna University decided to leave to single teachers the choice to make or not available the recordings of his/her lectures. This is a tricky matter due to Italian laws

Useful information

https://corsi.unibo.it/2cycle/Astrophysics

- **Sign up for the courses: Virtuale**
- **Sign up for the exams: Almaesami** (webpage→Studying→Exam dates)
- **Classrooms:** H, I, L, M (computer lab) in Ue3 + some in Ue1, Ue4
- **Course timetable:** https://corsi.unibo.it/2cycle/Astrophysics/timetable
- **Prof. Office hours:** each professor has office hours for students; better to send an email and ask for an appointment (individual webpages: https://corsi.unibo.it/2cycle/Astrophysics/faculty)

- **For information and problems, you can contact:**
  - Degree Program Offices: science.international@unibo.it; scienze.didattica@unibo.it
  - Coordinator: Prof. Cristian Vignali (IV floor, Via Gobetti 93/2, cristian.vignali@unibo.it)
  - Academic tutors: Lucia Fiorani (lucia.fiorani@studio.unibo.it)
    Giulia Congera (giulia.congera@studio.unibo.it)

- **Student Representatives:**
  - Marco Gherardelli: marco.gheradelli@studio.unibo.it
  - Lorenzo Vannini: lorenzo.vannini5@studio.unibo.it

- **Student opinions**

More or less after 2/3 of the planned lectures (end November, end April), you will be asked to express your opinions about each individual course: **do not neglect this process**, which is important for improving the quality of the service offered by the Master course. In case of problems, don't wait this survey: contact the teacher in advance, don't be shy!

- **International possibilities (Erasmus, etc.)**

There are several opportunities to carry out periods of your training abroad: Erasmus, Overseas, etc.: **try to exploit them** to enrich your experiences! There will be a devoted meeting (January) to present the different opportunities.

- **Scheduled suspensions of the lectures:** 4th Oct., 1st Nov., 8th Dec.

- **Apply to become tutor of the Master Course**

The call is now open. Tutors help the Coordinator in the surveys and can be a further point of contact between students, teachers, and coordinator.

https://bandi.unibo.it/s/aform9/aform-settore-servizi-didattici-scienze-cittadella-bandi-per-assegni-di-tutorato-per-i-corsi-di-studio-del-dipartimento-di-fisica-e-astronomia-sede-di-bologna-a-a-2024-25

Health and Safety training courses

In order to have access to laboratories, it is necessary to complete the **mandatory** training course by also attending module 1 (general training) and module 2 (specific training – part I) online.
For more information, please refer to this page and pay attention to the fixed dates
https://www.unibo.it/en/services-and-opportunities/health-and-assistance/health-and-safety/online-course-on-health-and-safety-in-study-and-internship-areas.

https://corsi.unibo.it/2cycle/Astrophysics/health-and-safety-mandatory-training

Participation is allowed **ONLY upon registration** on **SOL** (Studenti Online) – **Bookings**.
If students did not complete this course in the previous years, for any doubt or information and for the recognition of certificates, you can write to:
difa.formazionesicurezza@unibo.it (Marta Tessarolo)

AA2024-25 Timetable (I semester)

Master Degree in ASTROPHYSICS AND COSMOLOGY

First Semester, AY 2024/2025

Lectures begin on Monday 2024.09.23

TIMETABLE: MASTER DEGREE in ASTROPHYSICS and COSMOLOGY, FIRST YEAR

	Monday	Tuesday	Wednesday	Thursday	Friday
08 - 09					
09 - 10		CASTAT *Prof. Brighenti* ***M***		CASTAT *Prof. Brighenti* ***M***	
10 -11		CASTAT *Prof. Brighenti* ***M***		CASTAT *Prof. Brighenti* ***M***	
11 -12	GALF&E *Prof. Cimatti* ***H***	CASTAT *Prof. Brighenti* ***M***	AGN&BH *Prof. Vignali* ***L***	CASTAT *Prof. Brighenti* ***M***	
12 -13	GALF&E *Prof. Cimatti* ***H***		AGN&BH *Prof. Vignali* ***L***	CASTAT *Prof. Brighenti* ***M***	
13 -14					
14 -15	AGN&BH *Prof. Vignali* ***L***	GALF&E *Prof. Cimatti* ***L***	GALF&E *Prof. Cimatti* ***H***	STEVOL *Prof. Ferraro* ***L***	
15 -16	AGN&BH *Prof. Vignali* ***L***	GALF&E *Prof. Cimatti* ***L***	GALF&E *Prof. Cimatti* ***H***	STEVOL *Prof. Ferraro* ***L***	
16 -17	STDYNA *Prof. Ciotti* ***L***	STEVOL *Prof. Ferraro* ***L***	STEVOL *Prof. Ferraro* ***H***	STDYNA *Prof. Ciotti* ***L***	
17 -18	STDYNA *Prof. Ciotti* ***L***	STEVOL *Prof. Ferraro* ***L***	STEVOL *Prof. Ferraro* ***H***	STDYNA *Prof. Ciotti* ***L***	
18 -19					

After graduation

- ✓ Professional astrophysicist (research in astrophysics):
  - PhD in Astrophysics (3-4 years, in Italy or abroad)
  - Temporary (about 2-5 yr long) post-doc positions, Italy/abroad
  - Permanent researcher/professor in a university or research institute, Italy/abroad

- ✓ Job opportunities out of scientific research:
  - Applied research in industry (optics, aerospace, ...)
  - Data analysis
  - Software programming and development
  - Teaching of maths and physics
  - Science communication/journalism (TV, radio, newspapers, ...)
  - .....

Master Degree
(2 years)

Scientific Research

PhD in Astrophysics
(3-4 years)

Temporary
post-doc positions

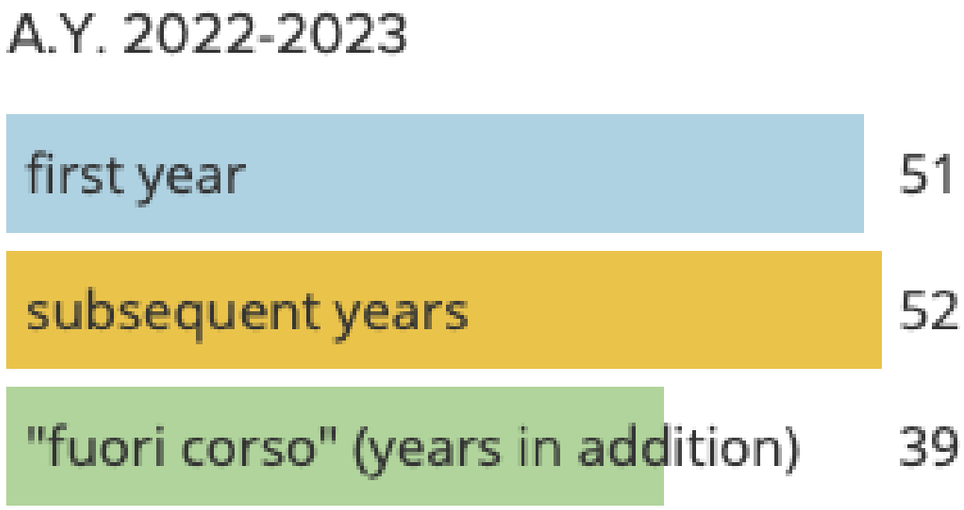
Researcher/professor
in universities or
research institutes

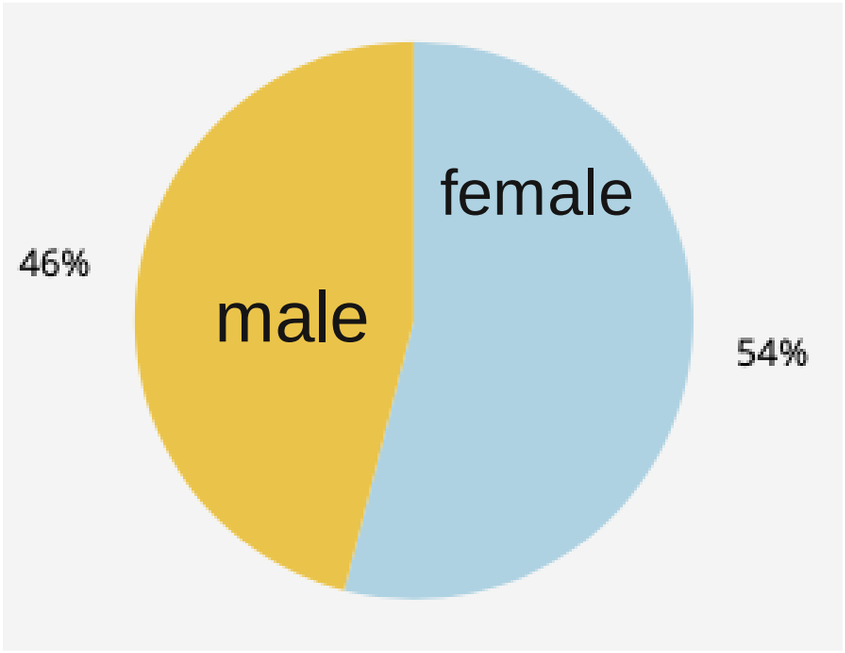
Job outside the scientific research

- Industry: optics, aerospace
- Software development
- Data analysis
- Teaching
- Science communication/journalism

Our Master program in a few numbers

Students enrolled





Programme attractiveness

Residents in other Italian regions

44%

Residents abroad

28%

Student satisfaction

Leaving students

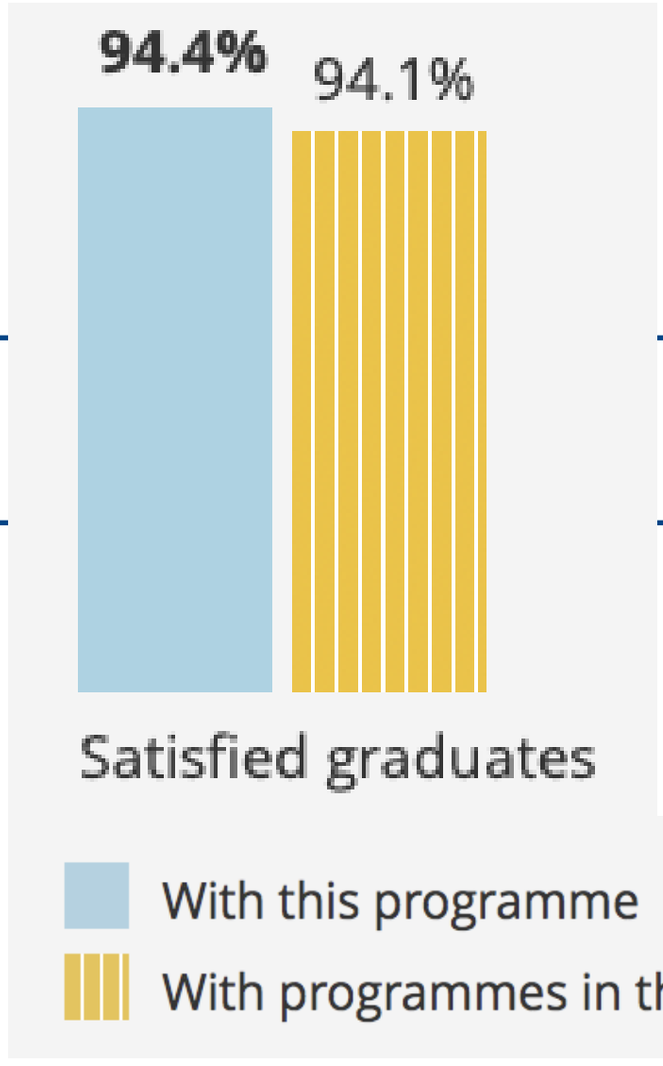
Students leaving university

4%

Students transferring to another programme

0%

96 % continue



JAMES WEBB SPACE TELESCOPE

CARINA NEBULA | NGC 3324

Enjoy the courses!

NIRCam Filters | F187N F444W F470N