

University of Bologna

Department of Physics and Astronomy

“Augusto Righi” (DIFA)

**MASTER DEGREE**

**in**

**ASTROPHYSICS AND COSMOLOGY**

# What is it?

## 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

# Five 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 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 (multiwavelength 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 institutes (OAS, IRA), all of them now in the Navile campus plus the headquarters of the Cherenkov Telescope Array, CTA
- About 40-50 PhD students (three years)
- $\gtrsim 40$  postdocs/contracts/etc.

# DIFA - 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



# What will you study?

- ❑ 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

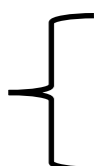
<b>FIRST YEAR</b>
STELLAR DYNAMICS
STELLAR EVOLUTION
GALAXY FORMATION AND EVOLUTION
ACTIVE GALACTIC NUCLEI AND SUPERMASSIVE BLACK HOLES
COSMOLOGY
COMPUTATIONAL ASTROPHYSICS AND STATISTICS
(from 1 to 3) ELECTIVE COURSES

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

**Total: 5 elective courses**

# Plan of the II Cycle Degree

<b>5828 – ASTROPHYSICS AND COSMOLOGY (LM58) Bologna</b>			
<b>First year</b>	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
<b>Elective course</b>		6	
<b>Free choice learning activities</b>		12	



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



**Total: 120 CFU**

# Elective courses (6 CFU each)

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

## 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 your choices.

**In mid October there will be a meeting where the contents of all possible elective courses will be presented (BUT see also the webpages for information)**

# About synergies among institutes in Bologna

## **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)**
- Comprises data analyses of stars, galaxies, and Active Galactic Nuclei, acquisition of expertise in the optical, radio, millimeter, and at high energies**

# Final examination

## **35 CFU, divided as follows:**

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

## **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 abroad (two calls per year for grants: Oct/Nov, March/April, stay tuned!)

## **Sessions:**

5 sessions every academic year: July, September/October (deadline for PhD), 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 organised in 2 PERIODS (SEMESTERS)**

**SEPT**

**DEC**



- Stellar evolution
- Stellar dynamics
- AGN and SMBH
- Galaxy Formation and evolution
- Computational Astrophysics and Statistics

**FEB**

**MAY**



- Cosmology
- **1-3 elective courses**

**FIRST  
YEAR**

**SEPT**

**DEC**



- Multiwavelength Astrophysics Lab.
- **2-4 elective courses**

**FEB**

**MAY**

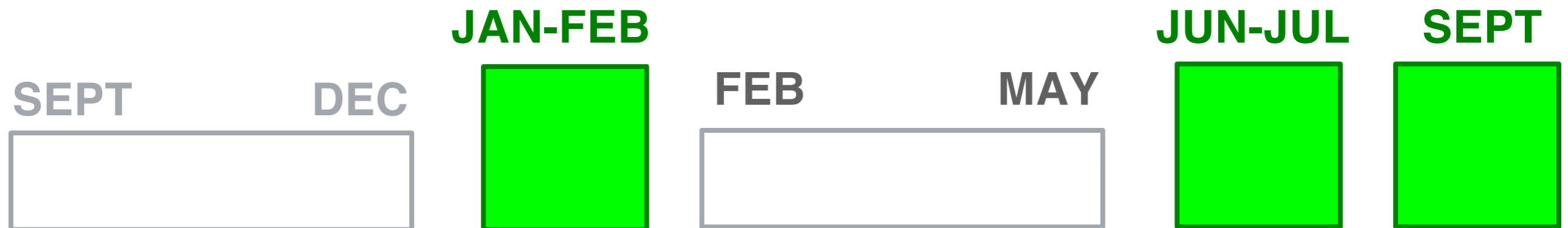


- Professional skills
- Master Thesis

**SECOND  
YEAR**

# Exam sessions

**EXAM SESSIONS** are organized in 3 PERIODS



**Each course will offer at least 6 possible dates**

**NO EXAMS OUT OF THE SESSIONS**

(exception for students «FUORI CORSO» i.e. after their 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](http://virtuale.unibo.it)). Please register!

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. I

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

- ❑ **Sign up for courses:** **Virtuale**
- ❑ **Sign up for exams:** **AlmaEsami** - see the webpage Studying → Exam dates
- ❑ **Classrooms:** see classrooms H, I, L, M (computing lab) + Ue1 classrooms
- ❑ Each teacher has an office hours for students; better to ask for an appointment with an email (see the webpage of each teacher:  
<https://corsi.unibo.it/2cycle/Astrophysics/faculty>)
  
- ❑ **For information and problems, you can contact:**
  - **Degree Program Offices:**  
[scienze.didattica@unibo.it](mailto:scienze.didattica@unibo.it), [science.international@unibo.it](mailto:science.international@unibo.it)
  - **Master degree coordinator:** **Prof. Cristian Vignali** (IV floor, Via Gobetti 93/2; [cristian.vignali@unibo.it](mailto:cristian.vignali@unibo.it))
  - **Student Representatives:**
    - Marco Gherardelli: [marco.gherardelli@studio.unibo.it](mailto:marco.gherardelli@studio.unibo.it)
    - Lorenzo Vannini: [lorenzo.vannini5@studio.unibo.it](mailto:lorenzo.vannini5@studio.unibo.it)
    - Luca Zucchi: [luca.zucchi5@studio.unibo.it](mailto:luca.zucchi5@studio.unibo.it)
  - **CdS tutors:** they will be defined (selected soon – see next slide)

## OTHER USEFUL INFORMATION. II

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

### ❑ 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!

### ❑ Tutors of the Master Course

The tutors help the Coordinator in the surveys and can be a further point of contact between students, teachers and coordinator (deadline: Oct. 9, h12)  
<https://bandi.unibo.it/s/aform9/aform-settore-servizi-didattici-scienze-bandi-per-assegni-di-tutorato-per-i-corsi-di-studio-del-dipartimento-di-fisica-e-astronomia-sede-di-bologna-a-a-23-24>

### ❑ 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: 4<sup>th</sup> Oct., 1<sup>st</sup> Nov., 8<sup>th</sup> Dec.

# 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:

<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>.

Moreover, we recommend students to participate in the specified course, in the established date, because the Department will not plan any further date

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.formazione sicurezza@unibo.it](mailto:difa.formazione sicurezza@unibo.it).

**ATTENTION:** a few days before the beginning of the course, students will receive an email with all the indications to participate on Teams by the teacher (**Rosa Brancaccio**: [difa.formazione sicurezza@unibo.it](mailto:difa.formazione sicurezza@unibo.it)).

# ALMA MATER *Fest*

<https://almamaterfest.it/international-activities-2023/>

## AMF is here!

Alma Mater Fest is coming back from September 27th to October 2nd! The event organized by the University of Bologna addressed to all its students.

6 days of shows, debates, lessons, sports, and many more interesting initiatives in Bologna and all over the Romagna Campuses.

Let's meet and discover the University of Bologna together.

**FROM 09.27  
TO 10.02.2023**

Official welcome for  
International students

MEETINGS | DEBATE | SPORTS | MUSIC  
WORKSHOPS | GUIDED TOURS  
EXHIBITIONS | ORIENTATION

DEBATE

MEETINGS

ORIENTATION

SPORTS

GUIDED TOURS

EXHIBITIONS

WORKSHOPS

MUSIC

**Wednesday  
september 27th**

Thursday  
september 28th

Friday  
september 29th

Saturday  
september 30th

Sunday  
october 1st

Monday  
october 2nd

# Timetable AA 2023/24, I semester

## Master Degree in ASTROPHYSICS AND COSMOLOGY

First Semester, AY 2023/2024

*Lectures begin on Monday 2023.09.25*

TIMETABLE: [MASTER DEGREE in ASTROPHYSICS and COSMOLOGY, FIRST YEAR](#)

	Monday	Tuesday	Wednesday	Thursday	Friday
08 - 09					
09 - 10	Grav. Waves in A&P Prof. Moresco/Nipoti <b>UE1</b>	CASTAT Prof. Brighenti <b>M</b>		CASTAT Prof. Brighenti <b>M</b>	
10 - 11	Grav. Waves in A&P Prof. Moresco/Nipoti <b>UE1</b>	CASTAT Prof. Brighenti <b>M</b>		CASTAT Prof. Brighenti <b>M</b>	
11 - 12	GALF&E Prof. Cimatti <b>H</b>	CASTAT Prof. Brighenti <b>M</b>	AGN&BH Prof. Vignali <b>L</b>	CASTAT Prof. Brighenti <b>M</b>	
12 - 13	GALF&E Prof. Cimatti <b>H</b>		AGN&BH Prof. Vignali <b>L</b>	CASTAT Prof. Brighenti <b>M</b>	
13 - 14					
14 - 15	AGN&BH Prof. Vignali <b>L</b>	GALF&E Prof. Cimatti <b>L</b>	GALF&E Prof. Cimatti <b>H</b>	STEVOL Prof. Ferraro <b>L</b>	
15 - 16	AGN&BH Prof. Vignali <b>L</b>	GALF&E Prof. Cimatti <b>L</b>	GALF&E Prof. Cimatti <b>H</b>	STEVOL Prof. Ferraro <b>L</b>	
16 - 17	STDYNA Prof. Ciotti <b>L</b>	STEVOL Prof. Ferraro <b>L</b>	STEVOL Prof. Ferraro <b>H</b>	STDYNA Prof. Ciotti <b>L</b>	
17 - 18	STDYNA Prof. Ciotti <b>L</b>	STEVOL Prof. Ferraro <b>L</b>	STEVOL Prof. Ferraro <b>H</b>	STDYNA Prof. Ciotti <b>L</b>	
18 - 19	Grav. Waves in A&P	optional course II yr			

# 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, ...)
  - .....

# After Graduation

Master Degree  
(2 years)



Scientific Research

PhD in Astrophysics  
(3-4 years)



Temporary  
post-doc positions

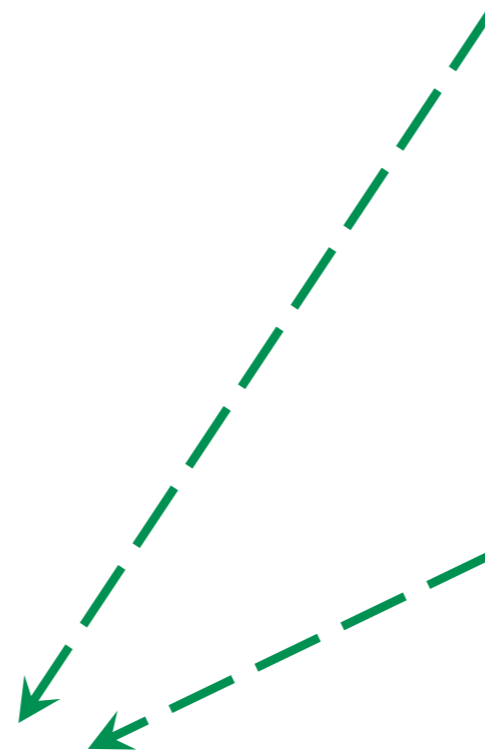


Researcher/professor  
in universities or  
research institutes



Job outside the scientific research

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



JAMES WEBB SPACE TELESCOPE

# CARINA NEBULA | NGC 3324

Enjoy the courses!



2 LIGHT-YEARS

NIRCam Filters

F187N F444W F470N