Master Degree Programme in Physics Handbook 2012/13

Index:

Introduction

The Master Degree Programme in Physics was born from the renewed cooperation between the University of Trieste and the University of Udine. Thanks to the presence of a rare concentration of laboratories and research facilities in the physics sector in Friuli Venezia-Giulia, particularly in Trieste, the Master Degree Programme in Physics offers unique research training opportunities for students. Many of the Professors of the Masters Degree Programme work in the laboratories as coordinators or co-operators, as well as in many International laboratories, where they carry out experimental, theoretical and computational researches in many areas of physics. Hence, students can live in a stimulating environment, which they can draw specialized knowledge from. This knowledge will be useful in their future career, either in the field of scientific research or in more technologically advanced sectors outside of the academic world.

Scholarships

The University College for Sciences "Luciano Fonda" grants scholarships to the students who enrol in the first year of the Master Degree Programme in Physics of the University of Trieste. The number of scholarships and their value vary according to the financial availability of the College. Some scholarships have been granted for the present academic year (2012/13); the call for applications should be posted in July. Information and the text

of the call can be found on http://www.collegio-scienze.trieste.it. For further information contact the Segreteria del Consorzio per la Fisica – Strada Costiera 11 – 34100 Trieste – Tel. 0039 040 224 0216 – Fax 0039 040 224 601 – e-mail: fisicons@ictp.it or write an e-mail to the University College for Sciences "Luciano Fonda" at collegio@ictp.it

Internationalization

The University of Trieste and the International Centre for Theoretical Physics (ICTP) “Abdus Salam” have been fruitfully cooperating in the formation of Master’s students in physics coming from developing countries since 2005/06. Furthermore, ICTP grants scholarships to those students every year. If foreign students are attending, lectures of the joint programme are held in English. Moreover, lectures of the core subjects common to all the courses are held in English. For further information: www.fisica.units.it (Didattica - Teaching), http://www.ictp.it/education-training.aspx and http://portal.ictp.it/tril/.

1) University qualifications

The Master Degree Programme in Physics, which lasts two years, is organized according to the DM 270/04. The students who pass the exams of the Master Degree Programme and successfully defend a Master thesis with an acknowledged scientific value on a topic of interest in the field of industry, research or education, obtain a Master’s degree in Physics.

For the academic year 2012/13, the Master Degree Programme in Physics (section LM17) consists of five courses:

1) Condensed Matter Physics;
2) Nuclear and Sub-nuclear Physics;
3) Theoretical Physics;
4) Earth and Environmental Physics
5) Astrophysics and Cosmology

These courses are part of the three curricula of the teaching plan (Microphysics and Condensed Matter; Theoretical Physics; Astrophysics and Cosmology, Earth and Environmental Physics).

2) Entrance requirements

1) To enter the Master Degree Programme in Physics it is necessary to have the acknowledged equivalent of a Bachelor degree, obtained either in Italy or abroad. Furthermore, it is necessary to have a thorough knowledge of mathematics and physics. In particular, it is necessary to have a basic knowledge and comprehension skills in:
   - Mathematical Analysis, Geometry and Linear Algebra, Computers – no less than 15 ECTs)
   - Classical Physics (Mechanics, Thermodynamics, Electromagnetism, Acoustics, Optics), Quantum Mechanics, Special Relativity, Condensed Matter Physics, Nuclear and Sub-nuclear Physics, Laboratory (execution of experiences and statistical data analysis) – no less than 30 ECTs
2) A committee (art. 3.11) will assess the necessary requirements to the admission to the Master's Degree. The applicants who meet the above-mentioned requirements must send to the committee (preferably via e-mail) their CV, including the syllabus and the title of their bachelor's thesis and final mark. All the documents must be sent following the instructions that can be found on the website of the University (see paragraph 4).
3) Through the CVs and, if necessary, an interview, the committee will assess the requirements to the admission to the Master's Degree. The applicants who own a Degree of Section 25 (Classe 25, former DM 509/99) or of Section L-30 (Classe L-30, former DM 270/04) with a final mark of at least 95/110 will enter the Master's Degree with no further assessment. To assess the necessary requirements to the admission to the Master's Degree, other applicants, who meet the basic requirements (paragraph 1), might be interviewed by the committee
4) The Academic Senate defines terms and conditions of enrolment, which are posted on the university website (www.units.it) and on the Department of Physics website (www.fisica.units.it didattica - teaching).

3) Academic calendar

The Academic year is divided in two terms (semestri) of 13 weeks each. The time between terms can be used to study and to prepare for the exams. The second term of the second year is used to write the Master's Thesis. For the current year (2012/13) the Academic Calendar is as follows:

SEMESTER	From	To
I	1st October 2012	18th January 2013
II	4th March 2013	7th June 2013

Usually, it is not possible to take an exam during terms. However, there are two exceptions: (i) exams for second-year students during the second term and (ii) exams for students who intend to graduate before time. Those students who want to graduate before time must agree their lecture list with the Teaching Committee (Commissione Didattica).

4) Curriculum, course objectives, lecture list

Curricula (to set a personal lecture list) and courses (course objectives and compulsory approved lecture lists) are attached (Attachment B2) to the Regulations of the Master Degree Programme in Physics.

5) Educational Syllabus 2012/13

The Syllabus 2012/13 of the Master Degree Programme in Physics is attached (Attachment B1) to the Regulations of the Master Degree Programme in Physics.

Services and Facilities

Department of Physics

Via A. Valerio, 2 – 34127 Trieste (University, Building F)

Switchboard/Caretaker's lodge: Tel. 0039 040 558 3353 Fax: 0039 040 558 3350

Web: http//:www.fisica.units.it

Time: Monday to Thursday 7.50 am – 7.00 pm Friday 7.50 am – 6.30 pm

Registrar's Office (Segreteria Didattica)

Via A. Valerio, 2 – 34127 Trieste (University, Building F, Room T10, ground floor)

Dott.ssa Silvana Palmiero tel. 0039 040 558 3378

e-mail: silvana.palmiero@ts.infn.it, presidenzaccdsfisica@units.it

Consulting hours: *Monday* 10.00 – 12.00, *Tuesday* 10.00 – 12.00, *Thursday* 9.00 – 11.00

Libraries

Scientific Library

Via A. Valero, 2 – 34127 Trieste - 1st floor – Tel: 0039 040 558 3374

Time: Monday to Friday 9.00 – 12.00

Students' Library (http://www.infis.units.it/biblioteca/)

Via A. Valero, 2 – 34127 Trieste - ground floor – Tel: 0039 040 558 3353

Time: Monday to Friday 2.00 pm – 3.00 pm

For further information and on-line services: http://www.units.it/

e-mail Registrar's Office (Segreteria Studenti Facoltà di Scienze MMFFNN) scmmffnn.studenti@amm.units.it

Attachment B2

Curriculum, Course Objectives and Lecture Lists

Didactics of the Master Degree Programme in Physics provides for three curricula, with five different courses and lecture lists. Some of the lecture lists are compulsory approved.

In this document can be found:

1. The three curricula provided by the didactics: in case of a personalized lecture list, it has to respect the partitioning of ECTs on the different sectors (SSD) of one of the curricula;
2. Courses and course objectives;
3. For each course:
    a. A table of the possible courses to arrange the lecture list and
    b. Compulsory approved lecture lists.

1. Curricula

Describing the different curricula, didactic works (**TAF**) are distinguished in:

- Characterizing (typology **B**)
- Related (typology **C**)
- Optional (typology **D**)
- For the final exam (typology **E**)
- Other activities (typology **F**)

Microphysics and Condensed Matter			
Typology	Area	SSD	ECTs
B	Experimental application	FIS/01, FIS/07	12
	Theoretical and of basics of physics	FIS/02	12
	Microphysical and of the structure of Matter	FIS/03, FIS/04	12
	Astrophysical, geophysical and spatial	FIS/05, FIS/06, GEO/10, GEO/12	6
C	Related		21
D	Optional		12
E	Final exam		40
F	Internship		5

Theoretical Physics			
Typology	Area	SSD	ECTs
B	Experimental application	FIS/01, FIS/07	12
	Theoretical and of basics of physics	FIS/02	12
	Microphysical and of the structure of Matter	FIS/03, FIS/04	12
	Astrophysical, geophysical and spatial	FIS/05, FIS/06, GEO/10, GEO/12	6
C	Related		21
D	Optional		12

E	Final exam		40
F	Internship		5

Astrophysics and Cosmology, Earth and Environmental Physics			
Typology	Area	SSD	ECTs
B	Experimental application	FIS/01, FIS/07	12
	Theoretical and of basics of physics	FIS/02	12
	Microphysical and of the structure of Matter	FIS/03, FIS/04	12
	Astrophysical, geophysical and spatial	FIS/05, FIS/06, GEO/10, GEO/12	6
C	Related		21
D	Optional		12
E	Final exam		40
F	Internship		5

2. Courses and Course Objectives, Lecture Lists

2.1 Microphysics and Condensed Matter

2.1.1 Condensed Matter Physics

Course Objectives

The course in Condensed Matter Physics aims to form graduates who have:

- A solid cultural grounding of experimental and/or theoretical condensed matter physics;
- A thorough knowledge of modern measurement instrumentation and technical analysis of data;
- A thorough knowledge of support mathematical and computer instruments;
- A high scientific and operative grounding in the characterizing disciplines of this course;
- Familiarity with the instrumentation and the techniques used in the laboratories and/or with numerical techniques;
- The fluent written and oral knowledge of at least one of the languages of the European Union, apart from Italian, and of disciplinary vocabulary;
- The ability to work in autonomy, also taking charge of projects and structures;
- The ability to use specific knowledge to create a model of complex physical systems and in the field of applied sciences.

Master graduates in condensed matter physics will work in the following fields: promotion and development of scientific and technological innovation, technology management and planning in areas interrelated with condensed matter physics. They will then be able to work in the industrial, environmental and health sector as well as in those of cultural goods and public administration. Moreover, they will promote high-level popularization of scientific culture with a particular attention to the theoretical, experimental and application

aspects of condensed matter physics. They will have an excellent grounding to face a PhD both in Italy and abroad.

Condensed Matter Physics - Lectures							
1st YEAR							
1st Semester	**SSD**	**TAF**	**ECTs**	**2nd Semester**	**SSD**	**TAF**	**ECTs**
Atomic and Molecular Physics	FIS/03	B	6	Related B (Condensed Matter Physics II)	FIS/03	C	6
Related A (Condensed Matter Physics I)	FIS/03	C	6	Laboratory of Condensed Matter Physics *Or* Laboratory of Computational Physics	FIS/01	B	6
Laboratory of Experimental Physics	FIS/01	B	6	Cosmology I	FIS/05	B	6
Field Theory I	FIS/02	B	6	Geometry and Topology in Electronic Structure *Or* Numerical Methods for Quantum Mechanics	FIS/02	B	6
Basics of Elementary Particle Physics	FIS/04	B	6	Optional A		D	6
Total 1st year ECTs							60
2nd YEAR							
1st Semester	**SSD**	**TAF**	**ECTs**	**2nd Semester**	**SSD**	**TAF**	**ECTs**
Related C: (Spectroscopy)	FIS/03	C	9	Thesis		E	30
Optional B		D	6				
Internship		F	5				
Thesis		E	10				
Total 2nd year ECTs							60

Compulsory approved Lecture List:

- Related A: Condensed Matter Physics I
- Related B: Condensed Matter Physics II
- Related C: Spectroscopy

Optional:

Part of the offered courses

- Optional A: Applications of the Synchrotron Radiation (FIS/03) *or* Basics of Surface Science (FIS/03);
- Optional B: Critical Phenomena (FIS/03) *or* Classical Simulation of Many-body Systems (FIS/03) *or* Complements of Theory of Condensed Matter (FIS/03)

NOTE:

- For the offered courses, the non-overlapping of timetables of other courses is guaranteed. In case of a multiple offer, lectures listed as alternative, which form the offer itself, could be on the same time.

2.1.2 Nuclear and Sub-nuclear Physics

Course Objectives

The course in Nuclear and Sub-nuclear Physics aims to form graduates who have:

- A solid cultural grounding of theoretical/phenomenological and/or experimental/application nuclear and sub-nuclear physics;
- A thorough knowledge of modern measurement instrumentation and technical data analysis;
- A thorough knowledge of support mathematical and computer instruments;
- A high scientific and operative grounding in the characterizing disciplines of this course;
- Familiarity with the instrumentation and the techniques used in the laboratories;
- The fluent written and oral knowledge of at least one of the languages of the European Union, apart from Italian, and of disciplinary vocabulary;
- The ability to work in autonomy and to take part in national and international scientific co-operations, also taking charge of projects and structures;
- The ability to use specific knowledge to create a model of complex physical systems and in the field of applied sciences.

Master graduates in nuclear and sub-nuclear physics will be able to work in the following fields: promotion and development of scientific and technological innovation, technology management and planning in areas interrelated with nuclear and sub-nuclear physics. They will then be able to work in the industrial, environmental and health sector as well as in those of cultural goods and public administration. Moreover, they will promote high-level popularization of scientific culture with a particular attention to the experimental and application aspects of nuclear and sub-nuclear physics. They will have an excellent grounding to face a PhD both in Italy and abroad.

Nuclear and Sub-nuclear Physics - Lectures							
1st YEAR							
1st Semester	**SSD**	**TAF**	**ECTs**	**2nd Semester**	**SSD**	**TAF**	**ECTs**
Field Theory I	FIS/02	B	6	General Characteristics of Detectors	FIS/01	B	6
Basics of Elementary Particle Physics	FIS/04	C	6	Laboratory of Data Acquisition and Control	FIS/01	B	6
Atomic and Molecular Physics	FIS/03	B	6	Nuclear Physics	FIS/02	B	6
Related A: Advanced Statistics for Data Analysis *Or* Imaging Methods in Medical Physics	FIS/01 FIS/07	C	6	Related B: Dynamics of Elementary Particles *Or* Laboratory of Medical Physics	FIS/04 FIS/07	C	6
				Cosmology I	FIS/05	B	6
Optional A						D	6
Total 1st year ECTs							60
2nd YEAR							
1st Semester	**SSD**	**TAF**	**ECTs**	**2nd Semester**	**SSD**	**TAF**	**ECTs**
Related C: Laboratory of Nuclear and Sub-nuclear	FIS/04	C	9	Thesis		E	30

Physics *Or* Laboratory of Data Analysis in Physics and High Energy Astrophysics	FIS/04						
Optional B		D	6				
Internship		F	5				
Thesis		E	10				
Total 2nd year ECTs							60

Compulsory approved Lecture List:

- None

Related

Related A One of the following:
Advanced Statistics for Data Analysis *or*
Imaging Methods in Medical Physics

Related B One of the following:
Dynamics of Elementary Particles *or*
Laboratory of Medical Physics

Related C One of the following:
Laboratory of Nuclear and Sub-nuclear Physics *or*
Laboratory of Data Analysis in Physics and High Energy Astrophysics

Optional A and B
Part of the offered courses
Nuclear and Sub-nuclear Astrophysics (FIS/04) 2nd Semester
Experimental Nuclear and Sub-nuclear Physics (FIS/04) 1st Semester
High Energy Astrophysics (FIS/04) 1st Semester
Introduction to Biophysics (FIS/07) 2nd Semester

2.2 Theoretical Physics

2.2.1 Theoretical Physics

Course Objectives

The course in Theoretical Physics aims to form graduates who have:

- An overall view on frontier issues in various areas of theoretical physics research, from elementary particles to complex systems, from new frontiers of quantum physics to the most recent developments in gravitational theories;
- A great ability to master abstract theoretical formulations as well as of producing practical models of physical systems;
- A thorough knowledge of support mathematical and computer instruments;

- A high scientific and operative grounding in the characterizing disciplines of this course;
- A thorough knowledge of modern measurement instrumentation and technical analysis of data;
- A good written and oral knowledge of at least one of the languages of the European Union, apart from Italian, and of disciplinary vocabulary;
- The ability to face new problems and to suggest solutions;
- The ability to work in autonomy and to take part in national and international scientific co-operations.

Master graduates in theoretical physics will be able to cope with high-level activities like research and development in the public and private sector on topics from basic physics to complex systems. They will be also able to work in the growing sector of scientific popularization and of the transfer of advanced knowledge. Moreover, they will have an excellent grounding to face a PhD both in Italy and abroad.

Theoretical Physics - Lectures							
1st YEAR							
1st Semester	**SSD**	**TAF**	**ECTs**	**2nd Semester**	**SSD**	**TAF**	**ECTs**
Field Theory I	FIS/02	B	6	Field Theory II	FIS/02	B	6
Atomic and Molecular Physics	FIS/03	B	6	Cosmology I	FIS/05	B	6
Basics of Elementary Particle Physics	FIS/04	B	6	Laboratory of Computational Physics	FIS/01	B	6
Related A		C	6	Laboratory II*	FIS/01	B	6
Related B		C	6	Optional A		D	6
Total 1st year ECTs							60
2nd YEAR							
1st Semester	**SSD**	**TAF**	**ECTs**	**2nd Semester**	**SSD**	**TAF**	**ECTs**
Optional B		D	6	Thesis		E	30
Related C		C	9				
Internship		F	5				
Thesis		E	10				
Total 2nd year ECTs							60

***Laboratory II** One of the following:
Laboratory of Data Acquisition and Control *or*
Laboratory of Condensed Matter Physics

Compulsory approved Lecture List:

- Related A, B, C: one of the offered courses

Related A, B and C

Part of the offered courses

- Advanced Quantum Physics (FIS/02) 1st Semester
- Statistical Mechanics (FIS/02) 1st Semester
- General Relativity I (FIS/02) 1st Semester
- General Relativity II (FIS/02) 1st Semester 2nd Year
- Introduction to Quantum Information (FIS/02) 2nd Semester

- Application of Group Theory to Physics (FIS/02) 1st Semester
- Dynamics of Elementary Particles (FIS/04) 2nd Semester

Courses part of other curricula

- Numerical Methods for Quantum Mechanics (FIS/02) 2nd Semester
- Geometry and Topology in Electronic Structure (FIS/02) 2nd Semester
- Cosmology II (FIS/05) 1st Semester 2nd Year
- Advanced Statistics for Data Analysis (FIS/01) 1st Semester
- Spectroscopy (FIS/03) 1st Semester 2nd Year
- Critical Phenomena (FIS/03) 1st Semester 2nd Year

NOTE:

- For the offered courses, the non-overlapping of timetables of other courses is guaranteed.
- "Related A, B and C" can become part of the Optional course (which can be formed by more than one exam, but will be counted as one when registered).

2.3 Astrophysics and Cosmology, Earth and Environmental Physics

2.3.1 Earth and Environmental Physics

Course Objectives

The course in Theoretical Physics aims to form graduates who have:

- A solid cultural grounding of theoretical/phenomenological and/or experimental/application on earth and environmental physics;
- A thorough knowledge of modern measurement instrumentation and technical data analysis;
- A thorough knowledge of support mathematical and computer instruments;
- A high scientific and operative grounding in the characterizing disciplines of this course;
- Familiarity with the instrumentation and the techniques used in the laboratories;
- The fluent written and oral knowledge of at least one of the languages of the European Union, apart from Italian, and of disciplinary vocabulary;
- The ability to work in autonomy also taking charge of projects and structures;
- The ability to use specific knowledge to create a model of complex physical systems and in the field of applied sciences, particularly of earth and environmental physics.

Master graduates in earth and environmental physics will be able to work in the following fields: promotion and development of scientific and technological innovation, technology management and planning in areas interrelated with earth and environmental physics. They will then be able to work in the industrial and health sector as well as in those of cultural goods and public administration. Moreover, they will promote high-level popularization of scientific culture with a particular attention to the experimental and application aspects of earth and environmental physics (e.g. management of natural risks). They will have an excellent grounding to face a PhD both in Italy and abroad.

Earth and Environmental Physics - Lectures							
1st YEAR							
1st Semester	**SSD**	**TAF**	**ECTs**	**2nd Semester**	**SSD**	**TAF**	**ECTs**
Field Theory I	FIS/02	B	6	Related C: Seismology and Geodynamics	GEO/10	C	6
Atomic and Molecular Physics	FIS/03	B	6	Laboratory of Computational Physics *Or* Laboratory of Data Acquisition and Control	FIS/01	B	6
Basics of Elementary Particle Physics	FIS/04	B	6	Cosmology I	FIS/05	B	6
Related A: Earth Physics	GEO/10	C	6	Geophysical Fluid Dynamics	FIS/02	B	6
Related B: Theoretical Seismology	GEO/10	C	6	Optional A		D	6
Total 1st year ECTs							60
2nd YEAR							
1st Semester	**SSD**	**TAF**	**ECTs**	**2nd Semester**	**SSD**	**TAF**	**ECTs**
Seismic and Volcanic Risk	FIS/07	B	6	Thesis		E	30
Optional B		D	6				
Internship		F	5				
Thesis		E	10				
Total 2nd year ECTs							57

Compulsory approved Lecture List:

- None

Related A, B and C

Part of the offered courses

- Earth Physics (GEO/10) 1st Semester
- Theoretical Seismology (GEO/10) 1st Semester
- Seismology and Geodynamics (GEO/10) 2nd Semester

Optional:

Part of the offered courses

- Physics of Atmosphere (FIS/06)

2.3.1 Astrophysics and Cosmology

Course Objectives

The course in Astrophysics and Cosmology aims to form graduates who have:

- An excellent knowledge and capability of scientific investigation;
- A solid cultural grounding of classical and basic physics;

- A thorough grounding of modern astrophysics and cosmology;
- A thorough knowledge of modern observational and data collection instrumentation, and of the relative analysis techniques;
- A thorough knowledge of support mathematical and computer instruments;
- A high scientific and operative grounding in the characterizing disciplines of this course;
- The fluent written and oral knowledge of at least one of the languages of the European Union, apart from Italian, and of disciplinary vocabulary;
- The ability to work in autonomy also taking charge of projects and structures;
- The ability to use specific knowledge to create a model of complex physical systems and in the field of applied sciences.

Master graduates in astrophysics and cosmology will be able to continue their grounding with a PhD in Physics, Astronomy or in any related discipline that will enable them to enter the world of research, which is essential in the University or in Research Corporations. More in general, this grounding will allow the student to enter the world of industry and of tertiary, which need high/level knowledge, great autonomy and ability to co-ordinate. Among the activities that master graduates in astrophysics and cosmology will be able to do are:

- Promotion and development of scientific and technological innovation in the field of astrophysics, cosmology and space, as well as management and planning of technologies;
- Planning in areas interrelated with astrophysical, cosmological and spatial disciplines in the industrial and health sector as well as in those of cultural goods and public administration;
- High-level astronomic and astrophysical popularization, as well as organization and management of popular projects and popularization of the scientific knowledge.

Astrophysics and Cosmology - Lectures							
1st YEAR							
1st Semester	**SSD**	**TAF**	**ECTs**	**2nd Semester**	**SSD**	**TAF**	**ECTs**
Related A: Astrophysics	FIS/05	C	6	Cosmology I	FIS/05	C	6
Field Theory I	FIS/02	B	6	Laboratory of Astronomic Technologies	FIS/01	B	6
Atomic and Molecular Physics	FIS/03	B	6	Related B: Evolution of Stars and Galaxies	FIS/05	C	6
Basics of Elementary Particle Physics	FIS/04	B	6	Optional A		D	6
Theoretical Astrophysics	FIS/02	B	6	Optional B		D	6
Total 1st year ECTs							60
2nd YEAR							
1st Semester	**SSD**	**TAF**	**ECTs**	**2nd Semester**	**SSD**	**TAF**	**ECTs**
Laboratory of Spatial Astrophysics	FIS/01	B	6	Thesis		E	30
Related C: Cosmology II	FIS/05	C	9				
Internship		F	5				
Thesis		E	10				
Total 2nd year ECTs							60

Compulsory approved Lecture List:

- None

Optional:

Part of the offered courses

Optional A:
Observational Astrophysics (FIS/05) 6 ECTs, 2nd Semester

Optional B:
Star Atmospheres (FIS/05) 6 ECTs, 2nd Semester
Self-gravitating systems (FIS/05) 6 ECTs, 2nd Semester
Intergalactic medium (FIS/05) 3 ECTs, 2nd Semester
Planets and Astrobiology (FIS/05) 3 ECTs, 2nd Semester
Space Meteorology and Climatology (FIS/05) 6 ECTs, 2nd Semester

NOTE:

- For the offered courses, the non-overlapping of timetables of other courses is guaranteed.

Attachment B1 to the Regulations

List of Lectures (44) with SSD, Specific Course Objectives and Preparation

Course typologies are lectures (A), in-class exercises (E) and laboratory exercises (L)
DM 270/04 art. 12.2.b-c

Didactic work	**Condensed Matter Physics I**
SSD	FIS/03
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	Transportation of free, non-interactive electrons. Lattices and crystal structures. Independent electrons in a periodic potential: exact results and approximate methods. Semi classical Bloch electron transport in electric and magnetic fields. Boltzmann equation.
Preparation	
Prerequisites	
Modules	

Didactic work	**Atomic and Molecular Physics**
SSD	FIS/03
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	To move from one-particle quantum mechanics to many-particle (identical and non-identical) quantum mechanics, within atoms and molecules. In particular, the following topics will be covered: 1) one-electron and many-electron atoms: hydrogen-like systems, exchange interaction, Hartree-Fock approximation, electronic correlation, spectroscopic terms and fine structure. 2) Molecules: Born-Oppenheimer approximation, ionic and covalent bonds, molecular orbital, roto-vibrational states.
Preparation	
Prerequisites	
Modules	

Didactic work	**Laboratory of Experimental Physics**
SSD	FIS/01
ECTs	6
Code	
Typology	72 h (A+L)
Specific Objectives	Thorough knowledge of some experimental methods and instruments currently used in the area of physical research. Here are some examples of experiments that might be carried out during the year: measurement of electrical, optical and transport properties of quantum confinement systems, nanowire and nanocontact conductivity, electronic spectroscopy with sub-nanometric resolution.

Preparation	
Prerequisites	
Modules	

Didactic work	**Condensed Matter Physics II**
SSD	FIS/03
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	Interacting electrons, shielding. Density functional. Homogeneous and inhomogeneous semi-conductors. Atomic magnetism and magnetism of solids. Superconductivity.
Preparation	Condensed Matter Physics I
Prerequisites	
Modules	

Didactic work	**Complements of Theory of Condensed Matter**
SSD	FIS/03
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	As a supplement to characterizing core subjects (mostly stationary states), the course aims at covering some topics of complements of mechanics which are particularly interesting for condensed matter physics. For example: - Evolution of systems with time-dependent Hamiltonian matrices (adiabatic, impulsive, ... approximation). - Finite symmetry groups and their irreducible representations, applications to quantum systems.
Preparation	
Prerequisites	
Modules	

Didactic work	**Laboratory of Condensed Matter Physics**
SSD	FIS/01
ECTs	6
Code	
Typology	72 h (A+L)
Specific Objectives	Knowledge of the most popularized experimental techniques to study the geometric and electrical properties of surface areas of solids. During in-class exercises: preparation and characterization of surface areas of transition metals. Objectives: (i) to introduce the students to the scientific instrumentation used in ultra high vacuum conditions, (ii) to develop abilities of critical analysis in measuring relevant physical magnitudes in the area of condensed matter physics and (iii) to improve the knowledge to carry of data analysis.
Preparation	
Prerequisites	

Modules	

Didactic work	**Geometry and Topology in Electronic Structure**
SSD	FIS/02
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	The course aims at studying the geometry of non-relativistic quantum mechanics, in the aspects concerning molecular and condensed state physics. The objectives are to give an overall view of phenomena which are apparently very different, but in which geometric and topological aspects are dominant. The following topics will be covered: Aharonov-Bohm effect, conical intersections in molecules, Barry's phases, quantum Hall effect, semi-classical transport, modern theories of polarization and of orbital magnetization, quantum metrics and electron localization, topological insulators.
Preparation	
Prerequisites	
Modules	

Didactic work	**Laboratory of Computational Physics**
SSD	FIS/01
ECTs	6
Code	
Typology	72 h (A+L)
Specific Objectives	Implementation and use of stochastic methods and their numerical applications (algorithms and justifications; balancing; error estimation); particularly: Monte Carlo methods for numerical integration in statistical mechanics.
Preparation	
Prerequisites	
Modules	

Didactic work	**Basics of Surface Science**
SSD	FIS/03
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	The course focuses on the description of the main physical phenomena, which characterize surface areas of solids and experimental techniques commonly used to study them. The course objective is for the students to develop the knowledge of the main physical/chemical properties of the surfaces of metals and semiconductors. The course also aims at developing the students' ability to analyze the relations between geometric and electronic structures, chemical properties of surfaces that are clean or covered with adsorbate.
Preparation	Condensed Matter Physics I
Prerequisites	

Modules	

Didactic work	**Numerical Methods for Quantum Mechanics**
SSD	FIS/02
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	The course aims at conveying basic elements that are necessary for the numerical resolution of numerical problems in non-relativistic quantum mechanics. Introduction of the notion of stability, numerical accuracy, complexity of algorithms, and convergence of results compared to calculation parameters through practical examples. Introduction to some of the techniques and methods that are most used in quantum simulations.
Preparation	
Prerequisites	
Modules	

Didactic work	**Applications of the Synchrotron Radiation**
SSD	FIS/03
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	Macroscopic dielectric theory. Quantum theory of optical transitions. Theoretical principles and experimental methods of techniques based on the synchrotron radiation: photoemission spectroscopy, X-absorption spectroscopy, resonant inelastic scattering, microscopy and imaging methods. Elements of group theory and its applications to spectroscopy. Generation of the synchrotron radiations and FEL radiations. Elements of X-ray optics.
Preparation	
Prerequisites	
Modules	

Didactic work	**Spectroscopy**
SSD	FIS/03
ECTs	9
Code	
Typology	72 h (A+E)
Specific Objectives	To give the students a basic grounding to understand the basic, theoretical and experimental principles of optical spectroscopy, of electrical photoemission from “core” level, of the valence band and of the elastic and inelastic scattering. After an introduction about the time evolution of quantum systems and the radiation-matter interaction, optical spectroscopy will be applied to the study of atoms, molecules and superconductive, magnetic and nanostructured systems.
Preparation	
Prerequisites	

Modules	

Didactic work	**Critical Phenomena**
SSD	FIS/03
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	Knowledge of the most important aspects of the phenomenology of critical phenomena and of their theoretical thermodynamic-statistical description. Ability to use, on a basic level, theories that are important to describe the phase transitions and critical phenomena and to understand recent literature on this topic.
Preparation	
Prerequisites	
Modules	

Didactic work	**Classical Simulation of Many-body Systems**
SSD	FIS/03
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	The course aims at giving necessary concepts and methods, from algorithms to data analysis techniques, for the dynamic simulation of multi-body systems ruled by classical mechanics. In particular, but not exclusively, it focuses on atomistic simulations. Its aim is to teach students how to conduct a simulation, including how to write or modify the necessary software.
Preparation	
Prerequisites	
Modules	

Didactic work	**Basics of Elementary Particle Physics**
SSD	FIS/04
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	To give the knowledge of the basics of sub-nuclear physics, particularly about the phenomenology and the experimental evidences: a general view of fundamental interactions and the lepton, meson and baryon classification; symmetries and conserved quantum numbers; hadron quark model; families of elementary fermions; hadron electromagnetic properties; properties of weak interactions and V-A theory of beta decay. Moreover, through exercises, students will learn how to evaluate cross sections and velocity of decay.
Preparation	
Prerequisites	
Modules	

Didactic work	**Nuclear Physics**

SSD	FIS/04
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	Nuclear decays: beta decay, gamma decay, alpha decay, Radon problem. Application of nuclear physics: solar fusion and solar neutrinos; artificial fusion; nuclear fission: fission of fissile nuclei and nuclear reactors, fission of fertile nuclei and energy amplifiers.
Preparation	
Prerequisites	
Modules	

Didactic work	**Advanced Statistics for Data Analysis**
SSD	FIS/01
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	References to statistics. Fundamental distributions, likelihood, parametric procedures of various kinds, valuation errors. Various examples of statistical data analysis taken from current experiments.
Preparation	
Prerequisites	
Modules	

Didactic work	**Imaging Methods in Medical Physics**
SSD	FIS/07
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	Conventional and digital radiology, by absorption and phase contrast. Application of the synchrotron radiation to medical physics. Tomography. Radioisotope imaging, SPECT and PET. Ultrasounds and scans. Nuclear magnetic resonance: general methods, spatial localization, fast and ultrafast methods.
Preparation	
Prerequisites	
Modules	

Didactic work	**General Characteristics of Detectors**
SSD	FIS/01
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	The course aims at giving the students the instruments necessary to understand how the main detectors used in experimental nuclear and sub-nuclear physics work. First will be studied the physical laws that rule the interaction of radiation, charged and neutral, with matter. Then will be studied the general characteristics of energy and position detectors, particularly some of the most used

	detectors.
Preparation	
Prerequisites	
Modules	

Didactic work	**Laboratory of Data Acquisition and Control**
SSD	FIS/01
ECTs	6
Code	
Typology	72 h (A+L)
Specific Objectives	Use of data acquisition instruments. Analogue and logic system. Application of modern software (Labview, Root) to different data acquisition standards (CAMAC, GPIB, VME/VXI)
Preparation	
Prerequisites	
Modules	

Didactic work	**Dynamics of Elementary Particles**
SSD	FIS/04
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	The course aims at giving the students the derivation of standard theory of fundamental interactions: i) general properties of Gauge and spontaneous breaking theories; ii) quantum chromodynamics, running coupling, asymptotic freedom, parton model, scale invariance violation, high p_T hadronic reactions; iii) Standard model of electroweak interactions, W and Z boson coupling, mass generation mechanism, CKM matrix, basics phenomenological aspects. Exercises consist of the calculation of simple reactions at the lowest order.
Preparation	
Prerequisites	
Modules	

Didactic work	**Laboratory of Medical Physics**
SSD	FIS/07
ECTs	6
Code	
Typology	72 h (A+L)
Specific Objectives	X-ray production and detection in diagnostic radiology. Digital radiology. Dosimetry in radiological exams. Nuclear magnetic resonance: morphological and functional imaging.
Preparation	
Prerequisites	
Modules	

Didactic work	**Nuclear and Sub-nuclear Astrophysics**
SSD	FIS/04
ECTs	6

Code	
Typology	48 h (A+E)
Specific Objectives	Astroparticle physics in universe evolution. Cosmic microwave background radiation. Radiation, matter, dark matter and dark energy. Theoretical, observational and experimental aspects of astroparticles. Cosmic rays in the space and in the atmosphere. Muons. Gamma rays. Neutrinos. Antiparticles. Detection. Propagation. Acceleration. Generation. Astrophysical point sources. Gamma-ray astronomy and neutrino astronomy. Gravitational star collapse. Dark matter. Gamma ray streams of cosmological origins. Extremely high-energy regions.
Preparation	
Prerequisites	
Modules	

Didactic work	**Laboratory of Nuclear and Sub-nuclear Physics**
SSD	FIS/04
ECTs	9
Code	
Typology	108 h (A+L)
Specific Objectives	The course aims at teaching students the modern experimental techniques used in nuclear and sub-nuclear physics. In particular, the students learn how to conduct particle detection experiments from the planning stage to the stages of production, data acquisition and analysis.
Preparation	
Prerequisites	
Modules	

Didactic work	**Laboratory of Data Analysis in Physics and High Energy Astrophysics**
SSD	FIS/04
ECTs	9
Code	
Typology	108 h (A+E+L)
Specific Objectives	The course aims at giving a panoramic view on some instruments for data analysis in physics and high-energy astrophysics and allowing a hands-on approach to the analysis itself. It is divided In modules that use instruments and data at the state of art, with a theoretical approach to problems, a description of the instruments, and a real case to deal with. At the end of the course the student will know what data analysis un various areas of experimental physics and high-energy astrophysics is.
Preparation	
Prerequisites	
Modules	

Didactic work	**Experimental Nuclear and Sub-nuclear Physics**
SSD	FIS/04
ECTs	6

Code	
Typology	48 h (A+E)
Specific Objectives	The course will aim at introducing the experimental topics of high-energy nuclear and sub-nuclear physics. During the course will be discussed some of the problems in measuring, and specifically analysing the mentioned area, aiming at giving a grounding that will be useful in planning an experiment and understanding its results.
Preparation	
Prerequisites	
Modules	

Didactic work	**Introduction to Biophysics**
SSD	FIS/07
ECTs	3
Code	
Typology	24 h (A)
Specific Objectives	The course is an introduction to some important aspects of biology, in which physical modelling and imaging have, or had, an important role. The course will include: the genetic code and the structure of DNA; chemical kinetics; the structure of proteins; Michaelis-Menten equation; electrostatics of proteins; protein-folding; hydrated proteins as vitreous systems; cellular biomechanics; cellular energetic balance; dynamics of cellular populations; thermodynamic and mechanic-statistical aspects of cells and unicellular organisms; scale laws; brief introduction to Computational Biophysics and Bioinformatics.
Preparation	
Prerequisites	
Modules	

Didactic work	**High Energy Astrophysics**
SSD	FIS/04
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	The course aims at studying the instruments and results in the area of high-energy astrophysics of particles. In particular, it will focus on the cosmic radiation of nucleons, photons and neutrinos; future possibilities connected to the instruments used to detect gravitational waves. Focus on the connection between these studies and basic physics (verifications will be carried out in extreme conditions of symmetries of nature, and research of new physics in conditions which are inaccessible in a laboratory).
Preparation	
Prerequisites	
Modules	

Didactic work	**Advanced Quantum Mechanics**
SSD	FIS/02
ECTs	6

Code	
Typology	48 h (A+E)
Specific Objectives	The course aims at giving the modern instruments to study complex phenomena in quantum mechanics, particularly those phenomena common to classical and quantum. The course is divided into two parts, the first being related to the analysis of open quantum systems (density matrix formalism, reduced density matrix, Joos-Zeh and Caldeira-Legget equation, Quantum Brownian Motion), the second being related to stochastic processes (measure theory: brief introduction and basic theorems, probability theory, random variables: definition and properties, stochastic processes: definition and examples, Markov processes, Wiener process, the connection to path-integrals, stochastic integral).
Preparation	
Prerequisites	
Modules	

Didactic work	**General Relativity I**
SSD	FIS/02
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	Lorentz transformations, special relativity. Basics of differential geometry; tensor calculus and analysis in Riemann spaces. Gravitational field in relativity equations. Main application of general relativity.
Preparation	
Prerequisites	
Modules	

Didactic work	**Introduction to Quantum Information**
SSD	FIS/02
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	Quantum theory of information studies the consequences of the use of quantum systems in the manipulation and transmission of information. Vast importance will be given to entanglement and its behaviour when noise and squandering are present. Apart from some of the main applications of entangled systems, like teleport and some basic computational protocols, will be analysed some of the most recent developments in ultracold atoms that allow to cross the so-called shot-noise limit in measuring physical parameters. The course aims at giving a panoramic view of the above-mentioned aspects.
Preparation	
Prerequisites	
Modules	

Didactic work	**Application of Group Theory to Physics**
SSD	FIS/02
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	Abelian groups, direct product. Homomorphism, isomorphism and automorphism, kernel and imaging. Finite groups. Invariant subgroups and quotient group. Continuous groups. Topological properties. Classical groups of matrices, exponential and the corresponding algebras. SU(2) and SO(3) groups. Euclid, Galileo, Lorentz and Poincarè. SL(2, C) group and Lorentz. Covering groups. Representations: homogeneous, faithful, equivalent. Representations in quantum mechanics, Wigner-Eckart's theorem. Runge-Lenz vector.
Preparation	
Prerequisites	
Modules	

Didactic work	**Field Theory I**
SSD	FIS/02
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	Introduction to classical field theory physics. Non-relativistic QFT (Schrödinger equation in canonical quantization) Canonical quantization of Klein-Gordon equation (neutral field and charged field) Dirac equation, Dirac matrices and notation Canonical quantization of the electromagnetic field Scattering theory Interacting fields, perturbative development, Wick-s theorem, Feynman rules. Calculation of Feynman Diagram in the first order.
Preparation	
Prerequisites	
Modules	

Didactic work	**Field Theory II**
SSD	FIS/02
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	Path-integral approach to scalar, fermion and gauge field theory. Parameters of a general diagram and superficial divergence degree. Proper-vertex and effective-action concepts. Renormalization and beta-function concepts. QED

	Ward identities in QED. Some QED effects as Lamb-shift.
Preparation	Field Theory I
Prerequisites	
Modules	

Didactic work	**Statistical Mechanics**
SSD	FIS/02
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	The course aims at giving the Master Degree students an introduction as much self-consistent as possible to some aspects of physics of many-body systems, particularly those connected to collective phenomena, to processes out of the equilibrium and to electronic transport in uni- and bi-dimensional system in presence (or not) of dissipation and disorder.
Preparation	
Prerequisites	
Modules	

Didactic work	**General Relativity II**
SSD	FIS/02
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	i) To understand the global structure of spacetime in General Relativity. ii) to develop instruments and techniques to detect the consequences of the presence of symmetries in general covariant theories. iii) to be able to phrase variational principles for general covariant theories. iv) to start developing the ability to apply the above-mentioned concepts to particular situations of current interest in astrophysics, cosmology and/or quantum gravity/string theory.
Preparation	General Relativity I
Prerequisites	
Modules	

Didactic work	**Advanced Mathematical Methods**
SSD	FIS/02
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	The course aims at being an introduction to the theory of second-order differential linear equations both ordinary and partial derivative. A study of the main special functions used in physics-mathematics follows. Particularly, it will cover the following topics: saddle-point method – ordinary second order linear differential equations – special functions – introduction to the theory of linear differential equations to partial derivatives.

Preparation	
Prerequisites	
Modules	

Didactic work	**Earth Physics**
SSD	GEO/10
ECTs	9
Code	
Typology	72 h (A+E)
Specific Objectives	The course aims at giving the basics to study the inner earth structure. Basic knowledge of elasticity, strain and deformations, and wave equation. Waves inside the Earth, their use to the localization of earthquakes and their measurement through seismometers. Study of earthquakes with a parametrization of their sources. Study of gravity and Earth. Measurements of gravity and their interpretation. Study of the earth magnetic field, of rock magnetization and spatial and temporal anomalies in the field. Basic knowledge on Earth-s heat flux. Heat flux in oceans and continents. Thermal structure of the mantle and the nucleus.
Preparation	
Prerequisites	
Modules	

Didactic work	**Theoretical Seismology**
SSD	GEO/10
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	The course aims at giving the basics to understand modern topics of the genesis and propagation of seismic waves. In particular it will be about: linear elasticity (equations of motions, elastic waves, fluctuation modes, dispersion, scattering and attenuation) – seismic sources (fundamental theorems of elasticity, momentum tensor, cinematic and dynamic models) – seismograms (Green's functions, point sources and extended sources, heterogeneous elastic means) – seismic moment and magnitude.
Preparation	
Prerequisites	
Modules	

Didactic work	**Seismology and Geodynamics**
SSD	GEO/10
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	The course aims at giving the basics to understand advanced seismologic problems: complex systems dynamics, medium term earthquake forecast, seismo-syntesis with applications to the definition of seismic danger and to geodynamics. In particular it will be about: low freedom degree complex systems dynamics and

	medium term earthquake forecast – Seismo-synthesis with applications to the definition of seismic danger even of industrial establishments with a potential high environmental impact – inverse problem and definition of earth physical-mechanical problems with applications from antiseismic engineering to geodynamics.
Preparation	
Prerequisites	
Modules	

Didactic work	**Geophysical Fluid Dynamics**
SSD	FIS/02
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	The course aims at giving a knowledge of fluid earth physics, learning the mathematical techniques that are necessary to understand relative analytical modelling: basics of fluid kinematics; motion, continuity and thermodynamic equations; parameterization of turbulence; rotating reference systems; inner waves, long gravity waves; phenomenology of big-scale vacuum; quasi-geostrophic; shallow-water; Ekman layers; homogeneous models; Rossby waves in the ocean and in the atmosphere; wind-driven ocean dynamics.
Preparation	
Prerequisites	
Modules	

Didactic work	**Seismic and Volcanic Risk**
SSD	FIS/07
ECTs	6
Code	
Typology	48 h (A+E)
Specific Objectives	The course aims at giving the basic knowledge of models of seismic and volcanic risk analysis: probabilistic and deterministic methods, vulnerability and risk, earthquakes and scenario and project events. In particular it will be about: seismicity – intensity and magnitude – seismic motion of the ground – site effects – engineering aspects – probabilistic evaluation of seismic risk – deterministic evaluation of seismic risk. Tsunami. Brief introduction to volcanology – volcanic risk – risk remission – eruption forecast – Etna's 2002 eruption – Stromboli's 2002-2003 eruptions – Vesuvius's activity.
Preparation	
Prerequisites	
Modules	

Didactic work	**Physics of Atmosphere**
SSD	FIS/06
ECTs	6
Code	

Typology	48 h (A+E)
Specific Objectives	The course aims at giving the conceptual and analytical instruments to understand and describe atmospheric phenomena, with a particular focus on thermodynamics and mesoscale dynamics. It will be about: mechanisms of interaction between atmospheric fluxes and orography, processes of precipitation formation, mechanisms at the base of atmospheric stagnation and pollutant transformation. Numerical simulations will be carried out using a non-hydrostatic atmospheric model.
Preparation	
Prerequisites	
Modules	

Didactic work	**Theoretical Astrophysics**
SSD	FIS/05
ECTs	6
Code	
Typology	48 h (A)
Specific Objectives	In the first part of the course, students will learn elements of differential geometry and tensor analysis to understand the equations of general relativity theories and their application to cosmologic problematic. In the second part of the course, students will get to know physical mechanism at the base of star structure and evolution.
Preparation	
Prerequisites	
Modules	

Didactic work	**Astrophysics**
SSD	FIS/05
ECTs	6
Code	
Typology	48 h (A)
Specific Objectives	Students will learn basic theoretical and phenomenological knowledge of Astrophysics and Astronomy, which are necessary to understand better subjects that are more specific. Spherical Atmosphere, Celestial Mechanics, Photometrical Concepts and Magnitudes, Radiation Mechanisms, Temperatures, Star Spectrums, Binary Stars and Stellar Mass, Star Structure and Evolution, Variable Stars, Interstellar Medium, Strar Groups and Clusters, Milky Way, Galaxies, Groups, Galaxy Clusters and Superclusters. Many exercises and seminars will be done.
Preparation	
Prerequisites	
Modules	

Didactic work	**Evolution of Stars and Galaxies**
SSD	FIS/05
ECTs	6
Code	

Typology	48 h (A)
Specific Objectives	Students will learn principles of stellar nucleosynthesis, from primordial nucleosynthesis to supernovae of various kinds. They will then learn the Hubble sequence of galaxies and the observational galaxy properties: principles of the chemical evolution of galaxies, stellar formation rate, mass initial function and star production of chemical elements; comparison between theoretical models and observations; spectrophotometric galaxy evolution; calculation of the evolution of bolometric luminosity and monochromatic luminosities for simple and complex stellar populations and comparison between observations; derivation of the age of astronomic objects using the photometric evolution and other methods. Age of the universe. Hubble diagram and universe deceleration paramenter.
Preparation	Theoretical Astrophysics
Prerequisites	
Modules	

Didactic work	**Star Atmospheres**
SSD	FIS/05
ECTs	6
Code	
Typology	48 h (A)
Specific Objectives	Students will learn absorption and remission thermal and non thermal processes of radiation. The problem of radiating transport in optical thin and thick mediums will be studied. Part of the course will aim at solving the radiating transport equation in case of stellar atmospheres with analytical and numerical methods and at discussing models of stellar photospheres both semi-empirical and theoretical.
Preparation	
Prerequisites	
Modules	

Didactic work	**Cosmology I**
SSD	FIS/05
ECTs	6
Code	
Typology	48 h (A)
Specific Objectives	During the first part of the course (3 ECTs) students will learn basics of General Relativity. In the second part they will get to know different cosmologic models, with the base of observational cosmology, the standard cosmologic model (Big Bang) and the basic events of cosmic evolution, with inflation theories, constant cosmology, dark matter and dark energy. There will be also talk of the origin and evolution of cosmic structures.
Preparation	
Prerequisites	
Modules	

Didactic work	**Laboratory of Astronomic Technologies**
SSD	FIS/01
ECTs	6
Code	
Typology	72 h (A+L)
Specific Objectives	To get the basic knowledge of astronomic phenomena. To understand the panoramic of telescopes and astronomic instruments in ground-based optical bands, both operative and in project. To get the basic knowledge of basics and of the state of telescope technologies and spectrographs to astronomic observations in ground-based optical band. To get the basic knowledge on the implementation of numerical models of astronomic observations, optical systems and atmospheric propagation for the quality analysis and the evaluation of observational limits.
Preparation	
Prerequisites	
Modules	

Didactic work	**Self-gravitating systems**
SSD	FIS/05
ECTs	6
Code	
Typology	48 h (A)
Specific Objectives	The course aims at giving the knowledge of some problematic of astrophysics connected to the study of the equilibrium and stability of non-colliding self-gravitating systems. The understanding of elements of statistical mechanics, connected to the study of the main distribution functions applied to models of gravitational balance models, will allow the students to understand the mechanisms at the base of formation and evolution of some astrophysical systems (especially elliptical galaxies and galaxy clusters). Students will learn the necessary knowledge to talk about collision of stellar systems. Students will learn the main observational problems concerning the above mentioned study and the methods, both classical and frontier, used to deal with them.
Preparation	
Prerequisites	
Modules	

Didactic work	**Observational Astrophysics**
SSD	FIS/05
ECTs	6
Code	
Typology	72 h (A+L)
Specific Objectives	First part: spherical astrophysics, coordinates, time. Observation of the sun, planets, comets, asteroids, stars, supernovae, stellar clusters, the Milky Way, galaxies, carried out by the INAF Observation Station in Basovizza. Second part: characteristics and methods of detection of

	electromagnetic waves, cosmic rays, neutrinos, gravitational waves. How to chose a telescope and/or the instrument that is more suitable to write a “successful proposal”.
Preparation	
Prerequisites	
Modules	Monodisciplinary. Two teachers.

Didactic work	**Intergalactic medium**
SSD	FIS/05
ECTs	3
Code	
Typology	24 h (A)
Specific Objectives	The intergalactic medium as an instrument of cosmologic analysis. From astrophysical observations to the properties of the intergalactic medium (IGM). GunnPeterson’s test and reionization of the universe. Evolution of Lyman’s forest. Probability of absorption by a galactic halo. Ionization, temperature, IGM metallicity. Clustering of Lyman’s forest. From transmission fluctuation of the intergalactic mean to density fluctuation of the Universe. Basic physics measurements: CBM temperature, the possible variation of fundamental constants. Direct measurement of the variation of the universe expansion rate (CODEX esperiment).
Preparation	
Prerequisites	
Modules	

Didactic work	**Planets and Astrobiology**
SSD	FIS/05
ECTs	3
Code	
Typology	24 h (A)
Specific Objectives	Main observational properties of the planets of the Solar System. The Earth-Moon System. Main satellites of giant planets. Minor bodies; asteroids and comets. Observational methods of extra solar planets. Main results of the exoplanet studies. Models of planet formation. Physical and chemical description of the main characteristics of terrestrial organisms. The environments of life on the earth; extremophilic organisms and their interest in astrobiology. Prebiotic material of astronomical origin. Interstellar molecules and organic material. Organic material in comets and meteorites. Evolution of life on Earth, main evolution stages; climate and evolution; time scale of evolution and astrobiological implications. Research of the life on the Solar System and outside it. Galactic habitability areas.
Preparation	
Prerequisites	
Modules	

Didactic work	**Laboratory of Spatial Astrophysics**
SSD	FIS/01

ECTs	6
Code	
Typology	72 h (A+L)
Specific Objectives	Analysis of the spatial environment: from the study of the sun and of the terrestrial atmosphere and their interaction, to astrodynamics with the study of orbits and of the characteristics of a spatial mission. Brief analysis of the systems forming a satellite: propulsion, stability, communication, structure and thermal. Laboratory applications and exercises with instrumentation and software.
Preparation	
Prerequisites	
Modules	

Didactic work	**Cosmology II**
SSD	FIS/05
ECTs	9
Code	
Typology	72 h (A)
Specific Objectives	Students will develop knowledge on methods to describe the formation and evolution of cosmic structures. The methods used will be analytic, semi-analytic and numerical-computational. Students will develop knowledge of the phenomenology of cosmic structures both on small-scale (galaxies) and on big-scale (galaxy clusters, big-scale structure of the Universe): study of the Sunyaev-Zeldovich effect, of gravitational lensing, statistics of large-scale distribution of galaxies and galaxy clusters, peculiar velocity fields.
Preparation	Cosmology I
Prerequisites	
Modules	

Didactic work	**Space Meteorology and Climatology**
SSD	FIS/05
ECTs	6
Code	
Typology	48 h (A)
Specific Objectives	The course aims at giving an introduction to space meteorology and climatology, that is to say the study of the phenomenology, modelling and observation of interactions between physical processes that originate in different astrophysical systems inside and outside the Solar System (from those which characterize the variability of the sun end of the heliosphere to high energy processes that originate Cosmic rays and Gamma ray burst) with planet environments and, as far as the Earth is concerned, with technological systems and living organisms.
Preparation	
Prerequisites	
Modules	Monodisciplinary. Two teachers.