MASTER IN ASTROPHYSICS

Main Language of Instruction:
French ☑ English ○ Arabic ○

Campus Where The Program Is Offered: CST

OBJECTIVES

The Master in Astrophysics is designed to train astrophysicists who will play a key role in setting up a network of observatories at national and regional levels.
The objectives of this Master's program are to:
- Provide future specialists with a high-level knowledge base and abstract skills in the scientific field of astrophysics.
- Train scientists capable of understanding the physical phenomena encountered, the description of celestial objects, and the methods and techniques used in the study of the sciences of the universe.
- Prepare students for PhD studies in all fields of applied physics.

PROGRAM LEARNING OUTCOMES (COMPETENCIES)

- Communicate scientific information relating to astrophysics and the sciences of the universe
- Design and manage a research project in astrophysics and the sciences of the universe.
- Solve complex problems and situations in astrophysics and the sciences of the universe.

ADMISSION REQUIREMENTS

Students with a Bachelor in Physics or an engineering degree from USJ or elsewhere (deemed equivalent by the USJ Equivalence Commission).

COURSES/CREDITS GRANTED BY EQUIVALENCE

048DRLTM1 - Law and Legislation (2 Cr.). 048IICPM1 - Industrial Computing (2 Cr.). 048ATCPM1 - Atomic and Molecular Physics (6 Cr.). 048SCOPM1 - Solid State and Semiconductor Physics (6 Cr.). 048NUCPM1 - Nuclear Physics (6 Cr.). 048QACPM1 - Advanced Quantum Physics (2 Cr.). 048TADTM1 - Data Processing and Analysis (6 Cr.). 048ETPTM2 - Entrepreneurship (6 Cr.). 048PMCPM2 - Condensed Matter Physics (4 Cr.). 048PEXCM2 - Experimental Design (2 Cr.). 048PVPTM2 - Professional Development (4 Cr.). 048PRMTM2 - Project Management (4 Cr.). 048DSCPM2 - Data Science in Physics (4 Cr.). 048OPCPM2 - Optics and Materials (4 Cr.).

PROGRAM REQUIREMENTS

Required Courses (120 credits)
Law and Legislation (2 Cr.). Industrial Computing (2 Cr.). Atomic and Molecular Physics (6 Cr.). Solid State and Semiconductor Physics (6 Cr.). Nuclear Physics (6 Cr.). Advanced Quantum Physics (2 Cr.). Data Processing And Analysis (6 Cr.). Entrepreneurship (6 Cr.). Condensed Matter Physics (4 Cr.). Observational Astrophysics (6 Cr.). Experimental Design (2 Cr.). Professional Development (4 Cr.). Project Management (4 Cr.). Data Science in Physics (4 Cr.). Cosmology (6 Cr.). Instruments and Techniques in Astrophysics (6 Cr.). Stellar Astrophysics (6 Cr.). Interstellar Medium (6 Cr.). Active Galaxies (3 Cr.). Circumstellar Environments (3 Cr.). End-of-Study Project (30 Cr.).

SUGGESTED STUDY PLAN

Semester 1

Code	Course Name	Credits
048DRLTM1	Law and Legislation	2
048IICPM1	Industrial Computing	2
048ATCPM1	Atomic and Molecular Physics	6
048SCOPM1	Solid State and Semiconductor Physics	6
048NUCPM1	Nuclear Physics	6
048QACPM1	Advanced Quantum Physics	2
048TADTM1	Data Processing and Analysis	6
	Total	**30**

Semester 2

Code	Course Name	Credits
048ETPTM2	Entrepreneurship	6
048PMCPM2	Condensed Matter Physics	4
048APOCM2	Observational Astrophysics	6
048PEXCM2	Experimental Design	2
048PVPTM2	Professional Development	4
048PRMTM2	Project Management	4
048DSCPM2	Data Science in Physics	4
	Total	**30**

Semester 3

Code	Course Name	Credits
048COSMM3	Cosmology	6
048TIACM3	Instruments and Techniques in Astrophysics	6
048APSCM3	Stellar Astrophysics	6
048MITCM3	Interstellar Medium	6
048GACCM3	Active Galaxies	3
048ENCCM3	Circumstellar Environments	3
	Total	**30**

Semester 4

Code	Course Name	Credits
048PFETM4	End-of-Study Project	30
	Total	**30**

COURSE DESCRIPTION

048DRLTM1	Law and Legislation	2 Cr.

The first part of this course aims to define intellectual property, which encompasses all exclusive rights granted for intellectual creations: legal rights to an idea, invention, or creation in industrial, scientific, literary, and artistic domains. The objective is to present the interests and advantages of such a concept before detailing the procedures for registering inventions or products.
The second part of this course aims to provide students with the set of rules governing interactions with citizens. It covers consumer law, business law, social law, labor law, as well as environmental law. These rules are codified, and students must be able to identify texts related to each domain to navigate them. It will include:

1. International environmental law and its application in Lebanon
2. Labor law
3. Social security law
4. Commercial law
5. Company law and industrial law.

048IICPM1	Industrial Computing	2 Cr.

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is the heart of a platform for the design of measurement and control systems, based on a graphical development environment from National Instruments. It is mainly used for data acquisition measurement, instrument control and industrial automation.

048ATCPM1	Atomic and Molecular Physics	6 Cr.

Atomic physics is a branch of physics that offers a wide range of phenomena and applications of classical and quantum physics at the macroscopic, microscopic and atomic scales. The aim of this course is to study the structure of atoms, physical and chemical processes and properties at the microscopic scale, and interactions with electromagnetic radiation. In addition, the course covers the various aspects of atomic physics, namely the physics of the atom, the physics of atoms (molecule physics and interatomic processes) and the fundamental and applied applications of atomic physics.

048SCOPM1	Solid State and Semiconductor Physics	6 Cr.

Solid state physics is the branch of physics that offers a wide range of phenomena and applications of classical and quantum physics on macroscopic, microscopic and atomic scales. For several decades, considerable research and development efforts have been devoted to this field, with a direct and undeniable impact on society's technological development. Topics covered include: properties of crystalline solids, electronic states in solids, properties of crystalline semiconductors, etc.

048NUCPM1	Nuclear Physics	6 Cr.

Nuclear physics is a discipline that today covers a vast and varied field of research: astrophysics, medicine, life sciences, engineering sciences and more. Its development has been extremely rapid thanks to its military and energy applications, which have provided researchers with considerable experimental resources. This course covers the basic principles of nuclear physics and its main applications. The course covers the properties of the nucleus, its structure and the binding energy of nucleons, nuclear transformations and emissions, and nuclear models.

048QACPM1	Advanced Quantum Physics	2 Cr.

Quantum mechanics, designed to explain atomic structure, was rapidly and successfully applied to the study of molecules and solids. It has proved highly fertile for the study of the structure of the nucleus and nuclear reactions, as well as for the physics of elementary particles. Quantum computing is currently the subject of intense research activity. This course should enable students to pursue specialized studies in one of the many fields requiring a good grounding in quantum mechanics. It also aims to familiarize them with the most important approximation methods in the many applications of quantum mechanics to contemporary mechanics.

048TADTM1	Data Processing and Analysis	6 Cr.

The "Data Processing and Analysis" course is divided into three main parts.

- The first part, "Metrology", introduces students to metrology, the science of measurement, providing them with the information they need to manage and control measurement processes and equipment.
- The second part, "Statistics", introduces students to the importance of statistics in data analysis, study planning and understanding the scientific literature.
- The third part, "Multivariate Analysis", is designed to equip students with the skills needed to use statistical tools to extract information and create new knowledge from complex databases obtained by analytical or other means. It involves simultaneously analyzing a set of explanatory variables and constructing multivariate models to describe, compare, classify and predict the characteristics of samples of individuals. Multivariate analysis is widely used in all fields of science, engineering, pharmacology, medicine, economics and sociology.

048ETPTM2	Entrepreneurship	6 Cr.

This course introduces students to entrepreneurship and provides them with the key tools any entrepreneur needs to succeed, including notions of accounting and finance. The first part of the course describes the role of entrepreneurs, analyzes the action of creating wealth and/or employment through the creation or takeover of a business, explains the different forms of entrepreneurship, addresses the concepts of creativity, innovation and market benefit, and supports the idea of risk-taking for the entrepreneur.
The second part provides an overview of the conceptual and regulatory framework underlying financial accounting, as well as an understanding of the content and structure of financial statements so as to be able to read them and understand what financial statements can and cannot reveal about a commercial or industrial institution. It also covers the different types of financial accounting information encountered in managerial life, providing a basic guide from accounting to cover all the important accounting concepts and managerial reporting tools that support appropriate managerial decision-making.
The final section aims to familiarize students with finance concepts and explain the basics of financial markets. Examples will help to apply the theories discussed in practice.

048PMCPM2	Condensed Matter Physics	4 Cr.

This course complements the "Solid State and Semiconductor Physics" course, with the main aim of showing the effects of phenomena observed at the atomic scale on the macroscopic properties of materials. Initially, the dielectric response function is discussed and its influence on the optical properties of materials explained. Next, the magnetic and electrical properties of materials are theoretically detailed at both atomic and macroscopic scales. Examples of industrial applications are inserted into the course to enable students to assess the usefulness of the theoretical models studied.

048APOCM2	Observational Astrophysics	6 Cr.

This course is a comprehensive course focusing on the tools and methodologies utilized in observational astrophysics during the early 21st century. Remarkable advancements in imaging and detection technologies have occurred in just over a decade, spanning adaptive optics, optical interferometry, sub-millimeter waveband observations, neutrino detections, and exoplanet discoveries. This course encompasses both ground-based and space-based astronomy, including forthcoming space missions. Covering the entire electromagnetic spectrum, it introduces emerging areas such as gravitational waves and neutrino astronomy. Additionally, it addresses numerical aspects such as signal processing, astronomical databases, and virtual observatories.

048PEXCM2	Experimental Design	2 Cr.

This course is an approach to the study of the methodology of experimental designs, which are robust measurement methods validated by means of multiple linear regressions, analysis of variance (ANOVA), and so on. Several designs are studied: complete two-level factorial designs, designs for second-degree models: complete three-level factorial designs, star-centered composite designs, Faces-centered composite designs, etc. The study strategy enables trials to be organized in such a way as to minimize study costs. Result processing enables the detection of significant effects and interactions between operating parameters. It also enables empirical modeling, obtaining response surfaces and searching for an optimum. This methodology is very useful in the food, biological and chemical industries. Design of experiments for formulation are also covered: unconstrained mixture design (type I), mixture design with constraints on lower limits (type II), mixture design with constraints on lower and upper limits with deformation of the parameter variation domain (type III). Statgraphics software is used to create the experimental designs.

048PVPTM2	Professional Development	4 Cr.

Industrial visits are designed to show the different stages of a given industrial production. They explain how the production unit works, how production is managed and controlled during the various stages, and how the final product is tested to ensure conformity. This course also covers the principles of analytical method development. In the M1 PCI program, this course consists of an internship under the supervision of an internship director. At the end of the internship, the student will write a detailed report on the personal work carried out, and present it to a jury made up of Master's instructors and representatives from the professional world.
The rules governing the presentation and grading of the report are as follows:

1. Oral presentation time is limited to a maximum of 20 min (plus 20 min for questions and 15 min for jury deliberation).
2. The final defense grade takes into account:
   - Oral presentation, including answers to questions
   - Internship supervisor's report
   - The form and content of the report, as assessed by the reviewers.

048PRMTM2	Project Management	4 Cr.

This course is an introduction to the fundamentals of project management: knowledge, techniques, methods and practices. It is fully aligned with the world's best-known international standards, those of the Project Management Institute, based on the two dimensions of project management, the 5-phase project life cycle: initiate, plan, execute, control and close, and the 10 knowledge categories.

048DSCPM2	Data Science in Physics	4 Cr.

The aim of this course is to prepare students for the analysis of scientific data. The types of data encountered in the field of physics are now well known, and the corresponding analysis tools are also available. Thus, this course serves as a basis for students to become aware of data analysis methods specific to the field of applied research, covering data considered manageable on a simple personal computer and massive data requiring more specific processing algorithms.

048COSMM3	Cosmology	6 Cr.

In the field of galaxies and cosmology, the last few years have seen dazzling advances, enabling us to see live the evolution of galaxies since their birth shortly after the Big Bang. Today, it is possible to see galaxies as they appeared in their early stages. These advances have also brought us new mysteries: the galaxies we see in the sky represent only a small part of the universe's content, the bulk of which is thought to be dark energy, in addition to dark matter, the nature of which is still unknown, and so on. In spite of this, we are gaining a better understanding of how galaxies form, assemble their mass, form their stars, and accumulate matter at their centers, in supermassive black holes, whose activity awakens from time to time to give rise to the ultra-luminous phenomenon of quasars. Even our own Milky Way galaxy is full of surprises, with countless new companions and satellites, many of which are now being digested to form the stellar halo. This course takes stock of what we know and what research is currently underway.

048TIACM3	Instruments and Techniques in Astrophysics	6 Cr.

The course aims at providing students enrolled in the Master in Astrophysics with an introduction to some of the basic software tools of astronomy. It also introduces them to modern geometrical optics and techniques for the calculation of properties of image forming set-ups with basic applications in the realm of astronomy. They develop their knowledge of these tools through numerical calculations and applications of relevance to the astronomical context. It helps students understand tools used in understanding optical configurations of telescopes and instruments as well as be able to compute some of the limitations and particulars of various designs.

048APSCM3	Stellar Astrophysics	6 Cr.

This course explores the diverse forms of interstellar media within our galaxy, alongside delving into the associated physical and chemical processes at play within this matter.

048MITCM3	Interstellar Medium	6 Cr.

This course explores the diverse forms of interstellar media within our galaxy, alongside delving into the associated physical and chemical processes at play within this matter.

048GACCM3	Active Galaxies	3 Cr.

This course is conducted solely through instructor-led lectures. The instructor adopts an interactive teaching style with a focus on elucidating processes rather than delving into equations. The methodology involves explaining concepts, demonstrating a few applications, and subsequently engaging the class in problem-solving exercises while seeking input from students throughout the derivation process. The content presented on the board will be influenced by the responses and contributions of the class, fostering an environment of active participation.

048ENCCM3	Circumstellar Environments	3 Cr.

Understanding circumstellar disks requires a broad range of scientific knowledge, including chemical processes, the properties of dust and gases, hydrodynamics and magnetohydrodynamics, radiation transfer, and stellar evolution – all of which are covered in this course, which will be indispensable for Master's students, seasoned researchers, or even advanced undergrads setting out on the study of planetary evolution.

048PFETM4	End-of-Study Project	30 Cr.

This course represents the end-of-study project for students, during which they will carry out an internship in industry or a research laboratory lasting between 4 and 7 months. At the end of the internship, students will write a detailed report on the personal work carried out and present it to a jury made up of Master's instructors and representatives from the professional world.
The rules governing the presentation and grading of the report are as follows:

1. Oral presentation time is limited to 20 min maximum (plus 20 min for questions and 15 min for jury deliberation).
2. The final defense grade takes into account:
   - Oral presentation, including answers to questions
   - The internship director's report
   - The form and content of the report, as assessed by the reviewers.