

# Master Physique

## Subatomic and Astroparticle Physics

### Présentation

#### English presentation:

[Website of the Master of Physics](#)

Recent advances in physics (high energy physics, quantum physics, condensed matter...) and related disciplines (astrophysics, life sciences, medical treatment and medical imaging...) are based on gathering, in laboratories or within national and international collaborations, a great diversity of skills and knowledge such as:

- Knowledge about fundamental theoretical and experimental physics;
- A broad view of the discipline: currently accepted theories, major open questions and plans to address them...
- Excellent knowledge of practical tools for modeling and analysis (mathematics, statistics, signal processing, database management, numerical simulations, instrumental developments);
- Ease with high-level experimental techniques;
- Teamwork and communication skills (project management, English, report writing, oral presentations).

The main objective of the Master of Physics is to train candidates to fit effectively into this framework, providing them with sound theoretical and practical bases, and giving them the opportunity to start specializing gradually through courses, personal projects and internships. The training aims to provide students with the necessary skills to carry out research and / or development work by focusing on:

- Autonomy in the analysis of a complex problem and the proposal of approaches (theoretical, numerical and / or experimental);
- Solid skills in computing (especially for the analysis of large datasets);
- Collaborative work;
- Ability to communicate scientific results.

The Master of Physics is a research-driven training, leading to fundamental or applied research, work in the *Science, Technology, Engineering and Mathematics* -STEM- industry (especially high-tech) and trades of education or dissemination of science. From a professional point of view, the training prepares either for a career as a researcher or a research engineer in the disciplinary fields concerned, or for a career in a sector where the knowledge and / or skills acquired as physicists prove to be useful. Thanks to a long-standing partnership with [Télécom Physique Strasbourg](#), the Master's degree also assumes the role of contributing to the formation of young engineers. In parallel with research-focused objectives, the Master of Physics also prepares students to pass the French recruitment competition for teachers Agrégation de Physique-Chimie, Option Physique through a specific track PA (Préparation à l'Agrégation). The mastery of the disciplinary foundations of Physics and Chemistry give rise to a solid theoretical and practical professional training in the trades of the education.

The Master of Physics consists of **7 tracks** with of a common first M1 year followed by a specialization at the M2 level. The content of each course is described in the specific pages. The courses are taught in English during the two years. For the main lectures, tutorial classes are duplicated with French and English teaching languages. M1 training consists of a common core of general physics taught through courses and tutorials in the first and second semester. Experimental training is an important part of the curriculum, with projects hosted by local laboratories. During these two semesters, optional courses allow students to discover the different possible tracks and specializations. The ties with ongoing academic research are ensured by weekly seminars given by researchers from Strasbourg laboratories during the first semester. In addition, students will train to actual research work via supervised projects and research internships in physics laboratories through (both in M1 and M2).

#### Résumé français:

Le master Physique de l'Université de Strasbourg est porté par la Faculté de Physique et

Composante	<ul style="list-style-type: none"> <li>• <a href="#">Faculté de physique et ingénierie</a></li> </ul>
Langues d'enseignement	<ul style="list-style-type: none"> <li>• Anglais</li> </ul>
Niveau d'entrée	BAC +3
Durée	2 ans
ECTS	120
Volume global d'heures	750
Formation à distance	Non, uniquement en présentiel
Régime d'études	<ul style="list-style-type: none"> <li>• FI (Formation initiale)</li> </ul>
Niveau RNCP	Niveau 7
RNCP	<ul style="list-style-type: none"> <li>• <a href="#">RNCP40720 : Master Physique</a></li> </ul>
Disciplines	<ul style="list-style-type: none"> <li>• Physique - Constituants élémentaires</li> <li>• Astronomie, astrophysique</li> </ul>
Lieu	<p>Master 1 : Campus Esplanade - Master 2 : Campus Cronenbourg : access to lecture room on Cronenbourg campus</p> <p>All lectures take place at IPHC on the Cronenbourg Campus. Two rooms are used : one is the Amphitheatre Grünwald located in the building 25 ; the other one is room 130 at the groundfloor of building 26 which is directly connected to building 20. You can ask for direction at welcome desk on the main campus building. You can find below a general map indicating the way.</p>
Campus	<ul style="list-style-type: none"> <li>• Campus Esplanade</li> <li>• Campus Cronenbourg</li> </ul>

Ingénierie, en partenariat avec [l'Observatoire d'Astrophysique de Strasbourg \(ObAS\)](#), [Télécom Physique Strasbourg \(TPS\)](#) et [l'École supérieure de biotechnologie de Strasbourg \(ESBS\)](#) et avec les [Instituts Thématiques Interdisciplinaires ITI/EUR HiFunMat, IRMIA++](#) et [QMat](#). Après une première année de formation généraliste fortement mutualisée, il propose 6 parcours orientés vers la recherche -Astrophysics and data science (Astro); Physics of Quantum and Soft Condensed Matter (PhyQS); Cell physics; Radiationation and imaging (PRIDI); Subatomic and astroparticle physics (SAP) and Quantum Technologies-European Program -s'appuyant sur les laboratoires Strasbourgeois et un parcours permettant de préparer le concours de recrutement de l'Agrégation de Physique-Chimie-Option Physique.

## Objectifs

### English version :

The Subatomic and astroparticles physics -SAP- master programme focuses on fundamental and applied research programmes conducted at facilities such as large centres in particle physics (for instance LHC at [CERN](#) in Geneva, or [JUNO](#) in China) or in nuclear physics (for instance SPIRAL at [GANIL](#) in France) and on the strong connections with modern cosmology and astrophysics. The two-year Master programme includes advanced lectures on theoretical methods and experimental techniques and requires active participation of the students in research projects to prepare them for a professional career in science.

**Learning by active participation in research** The educational programme is built around the wide range of research activities conducted at the [Institut Pluridisciplinaire Hubert Curien \(IPHC\)](#) hosting the second year specialisation of the Master. This assures close contacts between students and scientists participating in the Master programme via lectures and research projects proposed to students. In addition to theoretical physics IPHC has a long tradition in developing instrumentation for ambitious research programmes within large international collaborations. Scientists of the IPHC conduct world-class research in all current major centres and domains of subatomic physics.

The fundamental and applied research programmes in particle and nuclear physics, both connected to modern cosmology and astrophysics define the basic content of the second year of this Master.

The successful graduates acquire a solid expertise preparing them for the different phases of a scientific research programme in experimental or theoretical subatomic physics :

- Theoretical description and experimental aspects of a given physics problem
- Design study, development and realisation and comissioning of appropriate detection systems
- Data taking and data analysis
- Simulation of experiments and modelling of physical processes and phenomena
- Interpretation of the experimental results

### French version :

Le programme Master Physique subatomique et Astroparticules -PSA- se concentre sur des programmes de recherche fondamentale et appliquée menés auprès d'installations comme celles de grands centres de physique des particules (par exemple le LHC au [CERN](#) à Genève, ou [JUNO](#) en Chine) ou de physique nucléaire (par exemple SPIRAL au [GANIL](#) en France) et sur leurs liens étroits avec la cosmologie moderne et l'astrophysique. Le programme du Master est réparti sur deux ans et comprend des cours avancés, à la fois sur les principes théoriques et les techniques expérimentales, et nécessite une participation active des étudiants à des projets de recherche pour les préparer à une carrière professionnelle en science.

La formation via une participation active à la recherche constitue le socle du programme éducatif du Master PSA. Celui-ci est construit autour du large éventail d'activités de recherches conduites à l'[Institut Pluridisciplinaire Hubert Curien \(IPHC\)](#) qui accueille la deuxième année de spécialisation du Master. Cela permet des contacts étroits entre les étudiants et les scientifiques participant au programme du Master via des conférences et des projets de recherche proposés aux étudiants. En parallèle de travaux en physique théorique, l'institut possède une longue tradition dans le développement d'instruments de pointe pour des programmes de recherche ambitieux au sein de grandes collaborations. Les scientifiques de l'IPHC effectuent leurs recherches dans tous les grands centres et domaines actuels de physique subatomique.

Les programmes de recherche fondamentale ou appliquée en physique des particules et physique nucléaire, possédant des liens étroits avec la cosmologie moderne et l'astrophysique, définissent le contenu principal de la deuxième année de ce Master. Les futurs diplômés acquièrent ainsi une solide expertise à même de les préparer aux différentes phases d'un projet scientifique s'inscrivant dans un programme de recherche en physique subatomique expérimentale ou théorique :

- Description théorique et appréhension des aspects expérimentaux d'un problème de physique
- Étude de conception, développement, réalisation et mise en service de systèmes de détection

Secteurs d'activité	<ul style="list-style-type: none"> <li>• <a href="#">Recherche-développement en sciences physiques et naturelles</a></li> <li>• <a href="#">Industrie automobile</a></li> <li>• <a href="#">Fabrication de composants et cartes électroniques</a></li> <li>• <a href="#">Fabrication d'instruments et d'appareils de mesure, d'essai et de navigation ; horlogerie</a></li> <li>• <a href="#">Télécommunications</a></li> <li>• <a href="#">Recherche-développement scientifique</a></li> <li>• <a href="#">Activités pour la santé humaine</a></li> <li>• <a href="#">Programmation, conseil et autres activités informatiques</a></li> <li>• <a href="#">Enseignement secondaire</a></li> <li>• <a href="#">Enseignement supérieur et post-secondaire non supérieur</a></li> </ul>
Code ROME	<ul style="list-style-type: none"> <li>• <a href="#">Ingénieur / Ingénieure de recherche scientifique</a></li> <li>• <a href="#">Développeur / Développeuse informatique</a></li> <li>• <a href="#">Professeur / Professeure des universités</a></li> <li>• <a href="#">Expert / Experte systèmes et réseaux informatiques</a></li> </ul>
Stage	Oui
Alternance	Non

### Droits de scolarité

- To know about the registration fees, [check the dedicated page on the site of the University of Strasbourg](#)
- Pour connaître les droits de scolarité, consultez la page dédiée [sur le site de l'Université de Strasbourg](#).

### Contacts

#### Responsable(s) de parcours

- [Boris Hippolyte](#)

#### Responsable pédagogique

- [Dominique Aubert](#)

#### Responsable(s) de mention

- [Thierry Charitat](#)

#### Référent administratif

- [Rachida Azagouaghe](#)
- [Mathilde Battaglia](#)

- Prise de données et analyse des données
- Simulation d'expériences et modélisation des processus et phénomènes physiques
- Interprétation des résultats expérimentaux

#### English version :

**A two-year programme** The first year of the Master aims at providing a solid and broad base in theoretical and experimental physics and is shared by all specialisations : Condensed Matter and Nanophysics, Astrophysics and Physics of Radiation and Imaging techniques. Students from other universities, who have acquired this base, can join the Master Programme directly at the second year, where the specialisation takes place. In the **second year** the students attend advanced lectures in particle and nuclear physics and cosmology. The second semester is devoted to a full time research project (Internship or Master thesis). This phase represents a crucial step in our educational approach driven by active participation in research and aims at high qualification to prepare a Ph D thesis in France or abroad.

*Master supported by the French excellence initiative IdEx and included in the Graduate School [QMat](#) and Magistere [MdPF](#)*

#### French version :

**Un programme en deux ans :** la première année du Master, visant à fournir une base large et solide en théorie et physique expérimentale, est commune à toutes les spécialités : Physique Subatomique et Astroparticules, Matière Condensée et Nanophysique, Astrophysique et Physique du rayonnement et techniques d'imagerie. Les étudiants d'autres universités, qui ont acquis ces bases, peuvent intégrer directement le programme Master en deuxième année, où la spécialisation a lieu. En deuxième année les étudiants assistent à des cours avancés en physique des particules ainsi qu'en physique nucléaire et cosmologie. Le second semestre est consacré à un projet de recherche à temps plein (Stage ou Master thesis). Cette phase représente une étape cruciale dans notre approche pédagogique qui a pour fondement une participation active à la recherche et vise un haut niveau de qualification afin de préparer un doctorat thèse en France ou à l'étranger.

*Master soutenu par l'initiative d'excellence française IdEx et intégré à la Graduate School [QMat](#) et au Magistere [MdPF](#).*

#### Student project

After the 1<sup>st</sup> semester lectures focused on knowledge and before the master thesis, the 2<sup>nd</sup> semester starts with projects to strengthen scientific and technical skills. Students benefit from a rich choice of possibilities listed below .

Projects are evaluated by a panel of scientists in a similar way as the future master thesis. A short 2-page report is expected in the format of a standard scientific publication. Then students defend their projects for 15' in front of the committee, after which 15' of questions follow.

- **Solving a physics problem with computing (TIPP)** By group of two, students receive a simplified problem related to a research topic conducted in one of the IPHC groups. The game is to solve the problem with a computer program written from scratch and inspired by the statistical data analysis lecture. The program is elaborated from scratch, based on the tools seen during the first semester : ROOT, PYTHON, possibly GEANT4. The project span over 3-4 weeks and students are followed by a tutor for technical help. Results are then discussed with the research group and summarized in the form of a short scientific paper followed by a defense.
- **Performing a real subatomic experiment (EX<sup>2</sup>)** Thanks to the Excellence Initiative of the University of Strasbourg, various advanced experimental platforms allow students to perform real subatomic experiment on a small scale, under the supervision of a research group at IPHC. These platforms feature state-of-the-art detectors used for research. Within 3 to 4 weeks, each student group should elaborate and conduct their experiment, analyse the data and obtain the measurement a physical observable. In addition, a partial or complete simulation of the experiment might be implemented to allow a robust data interpretation. Results are then discussed with the research group and summarized in the form of a short scientific paper followed by a defense.  
*Exam : 2-page paper and oral defense*
- **QMAT Graduate School project** For QMAT students, initiative proposed in the context of the Graduate School (experimental projects, new lectures, schools, ...) can be validated.  
*Exam : 2-page paper and oral defense*
- **European School in Instrumentation (ESIPAP)** ESIPAP is a European school proposed advanced lectures on instrumentation for particle and astroparticle physics with specialists of the fields and hands-on practice at CERN. if the ESIPAP school is open during the academic year, Students might participate to the first module with other master students from all over Europe, instead of taking part to a project.  
Course details on the [ESIPAP page](#).  
*Exam : follows the examination rules of the ESIPAP school*

## Métiers visés

Our students pursue their career both in the public or private sector either after a successful PhD-thesis or directly after having completed the Master Diploma.

The career possibilities cover a large range of domains, both in fundamental and in applied research: Universities, CNRS, CEA, IRSN, EDF, ANDRA, Mirion Tech., international research organisations, companies developing detectors software algorithms (Big Data) and computing simulations.

## Les + de la formation

#### Targeted skills and knowledge :

- Science : understanding concepts and phenomena in subatomic and astroparticle physics, in particle detection and instrumentation, in computing and big data analysis.
- Research : modeling a physical problem within a given theoretical framework inventing, designing and simulating an experiment, analyzing and interpreting data.
- Project management : work impact and communicate in large international collaborations.

- Careers and alumni : the M2-SAP has a long history dating back from the 20th century, in the last ten years about 150 students graduated. Our alumni formed a group on the LinkedIn network, from which you will extract valuable contacts and information for your future career.

## Candidater

- Find out the information relative to [admission and registration on the site of the University of Strasbourg](#)
- Pour connaître les modalités de candidature, consultez [la page dédiée](#) sur le site de l'Université de Strasbourg.

## Prérequis obligatoires

### English version

#### I - At the M1 level

- All the courses of this master are taught in English. B2 level (CEFR scale) is required.
- Our master of Physics assumes that candidates should have a solid knowledge of classical mechanics and classical electrodynamics. The students should as well know and be able to apply the laws of quantum mechanics and statistical physics of free particles.
- Some experience with programming languages is needed.

#### II - At the M2 level

- All the courses of this master are taught in English. A B2 level (CEFR scale) is required.
- A knowledge of a programming language and algorithmic (Fortran, C, C ++, Python type) is necessary to be able to correctly follow the program.
- Candidates must have a strong background in modern physics (Electromagnetism, relativity, statistical mechanics, quantum mechanics).
- For « Condensed Matter and Nanophysics » program, they must have followed and validated at least two courses (at the introductory and advanced levels) of quantum mechanics, statistical mechanics and electromagnetism.
- For « Subatomic physics and astroparticles » program, they must have followed and validated at least two courses (at the introductory and advanced levels) of quantum mechanics and a course of subatomic physics (particles or nuclear).
- The Master's program is intensive, and it is not possible to have a parallel job. Financial resources must be guaranteed. Students with very good academic records may apply for the [Master QMat scholarship](#).
- solid knowledge of Quantum Mechanics and Special Relativity, introductory level in Subatomic Physics, Interaction of Radiations with Matter, basic skills in Programming and Scientific Numerical Methods.

### French version

#### I - Au niveau du M1

- L'ensemble des cours de ce master est enseigné en anglais. Un niveau B2 sur l'échelle du CECRL est nécessaire.
- Le master de physique suppose une solide connaissance de la mécanique classique et de l'électrodynamique classique. Les étudiants doivent avoir une formation de base en physique et être capable d'appliquer les lois de la mécanique quantique et de la physique statistique à des particules libres.
- Une expérience des langages de programmation est nécessaire.

#### II - Au niveau du M2

- L'ensemble des cours de ce master est enseigné en anglais. Un niveau B2 sur l'échelle du CECRL est nécessaire.
- Une connaissance d'un langage de programmation et de l'algorithmique (type Fortran, C, C++, Python) est nécessaire.
- Pour le parcours « Matière Condensée et Nanophysique », avoir suivi et validé au moins deux cours (introductif et avancé) de mécanique quantique, de physique statistique et d'électromagnétisme.
- Pour le parcours « Physique Subatomique et Astroparticules », avoir suivi et validé au moins deux cours (introductif et avancé) de mécanique quantique et un cours de physique subatomique (particules ou nucléaire).
- Il n'est pas possible de travailler en parallèle des cours, qui sont très denses. Les ressources financières doivent être garanties. Les meilleurs dossiers académiques peuvent se porter candidat à la [bourse de master QMat](#).

## Stage

### Internship and thesis

Type de stage

Type

Obligatoire - à faire, pour l'obtention de l'année

Lieu

Peut être fait à l'étranger

Semestre

Rythme de présence en structure d'accueil

Type de mission(s)

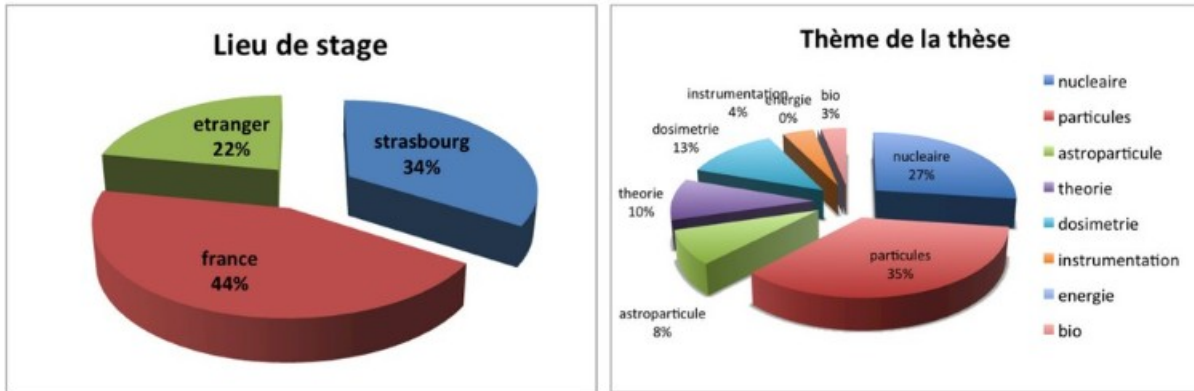
A Master Thesis concludes the programme with a minimum of three months research project in a laboratory. This internship allows to develop professional skills required by scientific work : problem analysis, autonomy, team work and results presentation. Students can pick any research subjects among the many ones proposed by IPHC or other international laboratories in France or abroad : for example IN2P3, CEA, CERN in France, GSI,

DESY, KIT in Germany, SCK-CEN in Belgium, STFC in UK.

The internship or master thesis is an essential part of the graduation process, allowing all students to have their first research experience. About 65% of our students continue with a PhD thesis.

Students can pick various thematic and locations for their internships and thesis. This is a distribution of their choices over the past ten years (see also the map below) :

- Internships and thesis [IPHC](#) :  
Each year, the lab hosting the M2-SAP propose a dozen of internships and thesis. Past and current subjects can be consulted on this [dedicated page](#).
- Proposals outside Strasbourg :  
The list of all external proposals and research labs in France and abroad is updated in the private site accessible to our student on [Moodle](#) .



# Programme des enseignements

## Subatomic and Astroparticle Physics

### Master 1 - Physique - Subatomic and Astroparticle Physics

Aucun contenu dans cette partie

### Master 2 - Physique - Subatomic and Astroparticle Physics

Semester 3 - Subatomic and Astroparticle Physics				
	CM	TD	TP	CI
Course unit: subatomic physics - Semestre 3	9 ECTS	-	-	-
Quantum field theory	22h	-	-	-
Nuclei and nucleon interactions	22h	-	-	-
Particle physics	22h	-	-	-
Astroparticles	14h	-	-	-
Course unit: instrumentation and modelisation - Semestre 3	6 ECTS	-	-	-
Radiation interaction with matter	14h	-	-	-
Detectors physics and detection systems	14h	-	-	-
Data analysis and modelisation	16h	-	-	6h
Course unit: elective compulsory classes (4 to choose among) - Semestre 3	12 ECTS	-	-	-
Liste UE3 Choix - <b>choisir 4 parmi 9</b>				
Theoretical aspects of Nuclear physics	20h	-	-	-
From nuclei to stars	20h	-	-	-
Theoretical aspects of Particle physics	20h	-	-	-
Beyond Standard Model	20h	-	-	-
General relativity and applications to cosmology	20h	-	-	-
Astro particles and observational cosmology	20h	-	-	-
Physics of nuclear reactors and other application of nuclear physics	20h	-	-	-
Quantum physics, Analytical mechanics, Special relativity	20h	-	-	-
Strong interaction at Hadronic Colliders	20h	-	-	-
Free course - Semestre 3	3 ECTS	-	-	-

	CM	TD	TP	CI
Liste UE4 Choix - Free - choisir 1 parmi 9				
Theoretical aspects of Nuclear physics	20h	-	-	-
From nuclei to stars	20h	-	-	-
Theoretical aspects of Particle physics	20h	-	-	-
Beyond Standard Model	20h	-	-	-
General relativity and applications to cosmology	20h	-	-	-
Astro particles and observational cosmology	20h	-	-	-
Physics of nuclear reactors and other application of nuclear physics	20h	-	-	-
Quantum physics, Analytical mechanics, Special relativity	20h	-	-	-
Strong interaction at Hadronic Colliders	20h	-	-	-

<b>Semester 4 - Subatomic and Astroparticle Physics</b>				
	CM	TD	TP	CI
Course unit: student project (1 to choose among) - Semestre 4	3 ECTS	-	-	-
Solving physics questions with computing	-	-	-	36h
Experimental platform (EX2)	-	-	15h	-
Module 1 of European School of Instrumentation in Particle and Astroparticle (Université Grenoble Alpes)	-	-	24h	14h
Course unit: professional integration - Semestre 4	3 ECTS	-	-	-
Professional integration	18h	-	-	-
Course unit: research internship - Semestre 4	24 ECTS	-	-	-
Long-term Internship (3 months minimum)	-	-	-	-
Liste facultative Facultatif				
Voluntary intership (diploma supplement) - Semestre 4	-	-	-	-
Liste UE4 Facultatif				
Voluntary internship	-	-	-	-