

PHYSICS
FACULTY OF SCIENCE
UNIVERSITY OF ZARAGOZA

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INTRODUCTION

FACULTY OF SCIENCE

The Faculty of Science is located at the heart of Zaragoza city, in San Francisco Campus. It has a long history of excellence in teaching and research. The Faculty has a strong international profile and attracts students from Europe and around the world. With more than 1,000 ISI journal articles published per year, the Faculty is a leading research hub at the University of Zaragoza, ranked among the top 200 world-class universities for Natural Sciences & Mathematics (ARWU 2016).

Figures for the Faculty of Science:

- 1850 students
- 450 professors + 100 researchers + 100 support staff
- 40 classrooms + 20 teaching labs + 150 research labs + 9 computer classrooms

Undergraduate Degree Programs

- BSc in Biotechnology
- BSc in Chemistry
- BSc in Geology
- BSc in Mathematics
- BSc in Optics and Optometrics
- BSc in Physics

MSc Degree Programs

- MSc in Geology: Techniques and applications
- MSc in Industrial Chemistry
- MSc in Mathematical modelling and research, Statistics and Computation
- MSc in Molecular and Cellular Biology
- MSc in Quantitative Biotechnology (*in English*)
- MSc in Molecular Chemistry and Homogeneous Catalysis
- MSc in Physics and Physical technologies
- MSc in Nanostructured Materials and Nanotechnological Applications (*in English*)
- MSc Erasmus Mundus in Membranes Engineering (*in English*)

English-language friendly (ELF) modules

Three of our MScs are taught in English, while the rest of MScs and all the BScs are taught in Spanish. However, in the programs taught in Spanish, most of the modules are English-language friendly. This means that, in those modules, foreign students will have, upon request:

- Learning material in English.

- Office hours in English.
- Assessment (exams, homework...) in English.

In the list of modules for each program, see below, English-language friendly modules for 2018/2019 are marked with an ^{ELF} label. The list of ELF modules may change slightly by 2019/2020; a list for that year will be available some weeks before the start of the classes.

High level research: More than 1.000 research papers in JCR per year

The Faculty has been the seed of Research Institutes of the University of Zaragoza:

- BIFI: Institute of Biocomputation and Physics of Complex Systems
- ICMA: Aragon Materials Science Institute
- INA: Institute of Nanoscience of Aragon
- ISQCH: Institute of Chemical Synthesis and Homogeneous Catalysis
- IUCA: Environmental Science Institute of Aragon
- IUMA: Institute of Mathematics and Applications

Most professors/researchers in the Faculty of Science are members of these institutes.

BSc IN PHYSICS

Duration: 4 years full time. 60 ECTS per year.

Language: Spanish.

Program aims:

The study of the different subjects taught in the Physics Degree allows students to understand the laws governing nature in all its dimensions, from elementary particles to the evolution of the universe. Students graduated in Physics are professionally trained in the scientific and technological field, to be able to use the general principles of Physics from the theoretical and experimental points of view, as well as specific measurement techniques and common instrumentation. Our Physics Degree program provides a solid mathematical background needed to analyze the different physical processes, and introduces students to advanced informatics tools required to carry out tasks of calculation, modeling and analysis of large volumes of information. This degree offers training particularly oriented towards research, innovation and development within multidisciplinary teams. It also allows students to access postgraduate programs.

Structure:

Year 1. In the first year students must enrol in the following modules:

Module	ECTS	Semester
26900 - Fundamentals of Physics I ^{ELF}	6	S1
26901 - Chemistry ^{ELF}	6	S1
26902 - Algebra I ^{ELF}	6	S1
26903 - Calculus ^{ELF}	6	S1
26904 - Computer Science ^{ELF}	6	S1
26905 - Fundamentals of Physics II ^{ELF}	6	S2
26907 - Algebra II ^{ELF}	6	S2
26906 - Physics Laboratory Work ^{ELF}	6	S2
26908 - Differential Calculus ^{ELF}	6	S2

S1: Semester 1. Mid-September to mid-January

S2: Semester 2. Beginning-February to end-May

^{ELF}: English-language friendly module (see first page)

In this first year they must also select one module from:

Module	ECTS	Semester
26909 - Biology ^{ELF}	6	S2
26910 - Geology ^{ELF}	6	S2

Year 2. In the second year students must enrol in the following modules:

Module	ECTS	Semester
26911 - Physical Techniques I ^{ELF}	8	YL
26912 - Classical Mechanics I ^{ELF}	7	S1
26913 - Integral Calculus and Geometry ^{ELF}	6	S1
26914 - Differential Equations ^{ELF}	6	S1
26915 - Electromagnetism ^{ELF}	8	S1
26916 - Classical Mechanics II	7	S2
26917 - Mathematical Methods for Physics ^{ELF}	6	S2
26918 - Computational Physics ^{ELF}	6	S2
26919 - Electromagnetic Waves ^{ELF}	6	S2

YL: Year-long. Mid-September to end-May

Year 3. In the third year students must enrol in the following modules:

Module	ECTS	Semester
26920 – Physical Techniques II ^{ELF}	10	YL
26921 - Quantum Physics I ^{ELF}	7	S1
26922 - Thermodynamics ^{ELF}	6	S1
26923 - Optics ^{ELF}	8	S1
26924 - Quantum Physics II ^{ELF}	8	S2
26925 - Statistical Physics ^{ELF}	6	S2

In the first semester of this third year they must also choose one module from those marked with a **3/4** in the list of optative modules below; in the second semester they must choose two modules from those marked with a **3/4** in the list of optative modules.

Year 4. In the fourth year students must enrol in the following modules:

Module	ECTS	Semester
26926 - Solid State I ^{ELF}	6	S1
26927 - Physical Techniques III ^{ELF}	6	S1
26928 - Physical Electronics	6	S1
26929 - Nuclear and Particle Physics ^{ELF}	6	S1
26930 - Solid State II ^{ELF}	6	S2
26931 – Undergraduate Dissertation * ^{ELF}	8	S2

In this fourth year they must also select four modules from the list of optional modules:

Module (optional for third and fourth year)	ECTS	Semester
26932 - Astronomy and Astrophysics ^{ELF} 3/4	5	S1
26936 - Business and Project Management ^{ELF} 3/4	5	**
26942 - Microwaves: Propagation and Aerials ^{ELF} 3/4	5	S1
26946 - Dosimetry and Radioprotection ^{ELF}	5	S1
26953 - Quantum Mechanics ^{ELF}	5	S1
26933 - Chaos and Nonlinear Dynamical Systems ^{ELF} 3/4	5	S2
26934 - Atmospheric Physics 3/4	5	**
26935 - Fluid Physics 3/4	5	S1
26937 - Gravity and Cosmology ^{ELF} 3/4	5	S2
26938 - History of Science 3/4	5	S2
26939 - Illumination and Colorimetry	5	S2
26940 - Laser and Applications ^{ELF} 3/4	5	S2
26941 - Micro and Nano-Systems ^{ELF} 3/4	5	S2
26944 - Applications of Diffraction and Interferometry	5	**
26945 - Devices and Photonic Systems ^{ELF}	5	S2
26947 - Spectroscopy ^{ELF}	5	S2
26948 - Critical Phenomena	5	**
26949 - Biological Physics ^{ELF}	5	S2
26950 - High Energy Physics ^{ELF}	5	S2
26951 - Nuclear Physics and Technology ^{ELF}	5	S2
26952 - Geophysics ^{ELF}	5	S2
26954 - Nanoscience	5	**
26955 - Optoelectronics	5	**
26956 - Radiation Detection Systems	5	**

26957 Digital systems	5	**
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Not all the optional modules are available every year. A list of the available modules for the following year (starting in September) is published in June. The modules with ** in the Semester column are not being offered in 2018/2019.

***Undergraduate Dissertation**

The Undergraduate Dissertation (UD) is a 200 hours project on any of the subjects of the degree. It is undertaken during the second semester of the 4th year. Students are supervised by a professor who defines the objectives of the Project and guides them along the work. Students must write a report and make a public defense of it. The following list includes of some examples of UDs performed in the last years.

- Numerical calculus in quantum theory of fields of condensed matter
- Verification system for integrated circuits in electronic labs
- Characterization and optimization of superconducting resonators with applications in quantum information
- Optoelectronic properties of graphene
- Geometric formalism in quantum mechanics and its applications
- Tensor dynamics in open Markovian systems
- Metapopulation methods for spread of diseases
- Particle physics in the hot Universe
- Computational modelling of nanostructures: Introduction to theoretical electroscopy
- A problem of interacting bosons. Numerical and analytical calculus
- Physics of Higgs boson at the LHC
- Quantum computation of magnetic molecules
- Synchronization in complex networks: Theory and applications
- Development of superconductor sensors of X ray for spacial missions
- Hamiltonian dynamical systems in quantum mechanics: Zenon effect
- Beyond special relativity: from microscopic to macroscopic systems
- Use of magnetic fields and nanoparticles for orientating neuronal cells
- Formation and evolution of stars

MSc IN PHYSICS AND PHYSICAL TECHNOLOGIES

Duration: 1 year full time. 60 ECTS.

Language: Spanish.

Program aims:

This Master Program aims to provide students with the ability to solve problems in new environments, integrate knowledge, develop theories or models from observational data and be able to work both independently and collaboratively. The graduates will acquire the research skills in one of the fields of Physics, in terms of the ability to conceive, design and carry out a research process and to communicate that knowledge to the scientific community and society.

Its main objectives are twofold:

- To train researchers with the capacity to join competitive research teams and be able to develop their own research activity.
- To form technologists with high scientific and technical skills, that enable them able to contribute to applications of Physics in industry, technology and other scientific fields and able to incorporate in companies of the technological innovation sector.

Structure:

The student must take enroll in the following modules (more information on Master's in Physics and Physical Technologies [website](#)):

Module	ECTS	Semester
<u>60025 - Research methodology in physics</u> ^{ELF}	6	S1
<u>60026 - Advanced topics in physics</u> ^{ELF}	6	S2
60027 – Master’s Dissertation * ^{ELF}	18	YL

They must also select 6 modules from the following list:

Module	ECTS	Semester
<u>60028 - Optics in the industrial environment</u>	5	S1
<u>60029 - Relativistic Astrophysics, Astroparticles and Cosmology</u> ^{ELF}	5	S1
<u>60030 - Material science</u> ^{ELF}	5	S1
<u>60036 - Intelligent Instrumentation</u> ^{ELF}	5	S1
<u>60037 - Interaction of radiation and matter</u> ^{ELF}	5	S1
<u>60038 - Nanoscience and nanotechnology</u> ^{ELF}	5	S1
<u>60039 - Security and industrial processes with laser</u> ^{ELF}	5	S1
<u>60042 - Quantum theory of condensed matter</u> ^{ELF}	5	S1
<u>60031 - Low temperature physics and quantum technologies</u> ^{ELF}	5	S2
<u>60032 - Comunication physics</u> ^{ELF}	5	S2

<u>60033 - Physics of magnetic materials</u> ^{ELF}	5	S2
<u>60034 - Particle physics</u> ^{ELF}	5	S2
<u>60035 - Statistical physics of critical phenomena and complex systems</u> ^{ELF}	5	S2
<u>60040 - Radiation detection systems</u> ^{ELF}	5	S2
<u>60041 - Imaging techniques and radiophysics</u> ^{ELF}	5	S2
60043 – Internship	5	YL

***Master's Dissertation**

The Master's Dissertation (MD) is a 450 hours compulsory project on some of the subjects of the degree. The following list includes some examples of MDs performed the last year.

- Coupling spin qubits to superconducting quantum circuits
- Structure and dynamics of multiplex networks
- Multiplex metapopulations in Ecology
- Background model for IAXO-D0, prototype of IAXO experiment.
- Development of metallic material cleaning processes using laser technologies. Application in heritage.
- Technical improvements in detection of significant mesoscalar singular structures using AEMET meteorological Doppler radar radial wind imagery.
- Design and fine-tuning of a holographic system for the measurement of the transport of magnetic particles in a capillary.
- Implementation of an actuation-readout multisensory system based on multicore processors.
- Optical vortex generation with holographic optical elements.

RESEARCH GROUPS IN PHYSICS

- **Processing and Characterization of Structural and Functional Ceramics.**
Director: Rosa Isabel Merino Rubio.
<http://www.icma.unizar-csic.es/ICMAportal/grupos.do?id=44>
- **Synchrotron Radiation and Materials: Basic Research and Applications**
Director: Fernando Bartolomé Usieto.
<http://www.icma.unizar-csic.es/ICMAportal/grupos.do?id=15>
<http://www.icma.unizar-csic.es/ICMAportal/grupos.do?id=14>
- **Preparation and Study of Multifunctional Magnetic Materials of Molecular Character.** Director: Javier Campo Ruiz
<http://icma.unizar-csic.es/ICMAportal/grupos.do?id=39>
<http://www.unizar.es/m4>
<http://www.icma.unizar-csic.es/ICMAportal/grupos.do?id=34>
- **Nanomanufacturing and advanced microscopies.** Director: José María De Teresa Nogueras
<http://www.icma.unizar-csic.es/ICMAportal/grupos.do?id=56>
- **Research on Retina and Visual System.** Director: Isabel Pinilla Lozano.
- **Laser & Optical Technologies.** Director: Juan Antonio Vallés Brau.
<http://i3a.unizar.es/en/research-groups/laser-optical-technologies>
- **Statistical and Non Linear Physics Group.** Director: Juan José Mazo Torres.
<http://complex.unizar.es/>
- **Nanostructured Active Materials.** Director: Miguel Ciria Remacha.
- **Electronic Design Group.** Director: Santiago Celma Pueyo
<http://gde.unizar.es/>
- **Nuclear and Astroparticle Physics.** Director: Eduardo García Abancéns.
<http://gifna.unizar.es/gifna/>
- **High Energy Physics.** Director: Manuel Asorey Carballeira.
<http://dftuz.unizar.es/ftzar/research/hep-th.html>
- **Magnetism in Nanostructures and its Applications.** Director: M: Ricardo Ibarra García
<http://magna.unizar.es>
- **Mathematical Physics and Fractal Geometry.** Director: Eduardo Martínez Fernández.
- **Liquid Crystals and Polymers.** Director: José Luis Serrano Ostáriz.
http://www.unizar.es/liquid_crystals/
- **Materials and Laser Treatment for Energetic Yield Improvement.**
Director: Rafael Navarro Linares.
<http://www.icma.unizar-csic.es/ICMAportal/grupos.do?id=18>

<http://www.icma.unizar-csic.es/ICMAportal/grupos.do?id=53>

- **Photonic Technologies Group.** Director: Rafael Alonso Esteban
http://gtf.unizar.es/index_es.php
- **Biofunctionality of Nanoparticles and Surfaces.** Dir: Jesús Martínez De La Fuente
<http://bionanosurf.unizar.es/>
- **Quantum Materials and Devices.** Director: Luis Martín Moreno.
<http://molchip.unizar.es/>
- **Inorganic Molecular Architecture and its Applications.** Director: Cristina Tejel Altarriba
- **Supercomputation and Physics of Complex and Biological Systems.** Director: David Iñiguez Dieste.
- **Computational Fluid Mechanics.** Director: Pilar García Navarro.
<http://mfc.unizar.es/>

LIST OF SELECTED RECENT PUBLICATIONS

G. Larraz, A. Orera, J. Sanz, I. Sobrados, V. Díez, M.L. Sanjuán. NMR study of Li distribution in $\text{Li}_{7-x}\text{HxLa}_3\text{Zr}_2\text{O}_{12}$ garnets. *Journal of Materials Chemistry A* 3 (2015), 5683-5691.

F. Bartolomé Usieto; L. Badía; M. Parra-Borderías; J. Rubin; F. Wilhelm; A. Rogalev; J. Bartolomé Sanjoaquin. Negative Magnetization in $\text{NdFe}_x\text{Ga}_{1-x}\text{O}_3$ Studied by XMCD. *Solid state phenom.* (online), 2017, vol. 257, p. 119-122

V.M. Orera, M.A. Laguna-Bercero, A. Larrea. Fabrication methods and performance in fuel cell and steam electrolysis operation modes of small tubular solid oxide fuel cells: a review. *Frontiers in energy research* 2 (2014), 1-22.

M.F. Acosta García, S. Ganschow, D. Klimm, S. Serrano Zabaleta, A. Larrea, R.I. Merino. Directional solidification of the eutectic LiF-LiYF_4 using Bridgman and micro-pulling down techniques: Microstructural study and some properties. *Journal of the European Ceramic Society* 34 (2014), 2051-2059.

F.M. Costa, N.M. Ferreira, Sh. Rasekh, A.J. S. Fernandes, M.A. Torres, M.A. Madre, J.C. Diez, A. Sotelo. Very large superconducting currents induced by growth tailoring. *Crystal Growth & Design* 15 (2015), 2094-2101.

Y.A. Attia, M.T. Flores-Arias, D. Nieto, C. Vazquez-Vazquez, G.F. de la Fuente, M.A. Lopez-Quintela. Transformation of gold nanorods in liquid media induced by nIR, visible, and UV laser irradiation. *Journal of Physical Chemistry C* 119 (2015), 13343-13349.

D. Flahaut, J. Allouche, A. Sotelo, Sh Rasekh, M.A. Torres, M.A. Madre, J.C. Diez. Role of Ag in textured-annealed $\text{Bi}_2\text{Ca}_2\text{Co}_{1.7}\text{O}_x$ thermoelectric ceramic. *Acta Materialia* (DOI: 10.1016/j.actamat.2015.09.036)

Materials Characterization by Synchrotron Radiation (CAMRADS). Director: Joaquin García Ruiz. V. Cuartero, J. Blasco, G. Subias, J. Garcia, C. Meneghini, G. Aquilanti. Stability of Jahn-Teller distortion ordering in $\text{LaMn}_{1-x}\text{Sc}_x\text{O}_3$. *Physical Review B* 92 (2015), 125118.

S. Lafuerza, G. Subias, J. Blasco, J. Garcia, G. Nisbet, K. Conder, E. Pomjakushina. Determination of the charge-ordered phases in LuFe_2O_4 . *Europhysics Letters* 107 (2014), 47002.

- V. Cuartero, S. Lafuerza, G. Subias, J. Garcia, E. Schierle, J. Blasco, J., Herrero-Albillos. X-ray magnetic circular dichroism study of the magnetic anisotropy on TbMnO₃. *Physical Review B* 91 (2015), 165111.
- I. Andreu, E. Natividad, L. Solozábal, O. Roubeau. Nano-objects for addressing the control of nanoparticle arrangement and performance in magnetic hyperthermia. *ACS Nano* 9 (2015), 1408-1419.
- R. Ottini; C. Tealdi; C. Tomasi; I.G. Tredici; A. Soffientini; R. Burriel; E. Palacios Latasa; M. Castro; U. Anselmi-Tamburini; P. Ghigna,; G. Spinolo. Local environments and transport properties of heavily doped strontium barium niobates Sr_{0.5}Ba_{0.5}Nb₂O₆. *J. solid state chem.* (online), 2018, vol. 258, p. 99-107
- E. Palacios, J. Bartolomé, G. Wang, R. Burriel, K. Skokov, S. Taskaev, V. Khovaylo. Analysis of the magnetocaloric effect in Heusler alloys: study of Ni₅₀CoMn₃₆Sn₁₃Nb_y calorimetric techniques. *Entropy* 17 (2015), 1236-1252.
- S. Perches, J. Ares, V. Collados, F. Palos. Sphero-cylindrical error for oblique gaze as a function of the position of the centre of rotation of the eye. *Ophthalmic and Physiological Optics* 33 (2013), 456–466.
- P. Rodríguez, R. Navarro, J.J. Rozema. Eigencorneas: application of principal component analysis to corneal topography. *Ophthalmic and Physiological Optics* 34 (2014), 667-677.
- C. Ferreira¹, J.L. López, R. Navarro, E. Pérez Sinusía. Zernike-like systems in polygons and polygonal facets. *Applied Optics* 54 (2015), 6575-6583.
- V. Palero, J. Lobera, N. Andrés, M. P. Arroyo. Shifted knife-edge aperture digital in-line holography for fluid velocimetry. *Optics Letters* 39 (2014), 3356-3359.
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- D. Aguilà, L.A. Barrios, V. Velasco, O. Roubeau, A. Repollés, P.J. Alonso, J. Sesé, S. J. Teat, F. Luis, G. Aromí. Heterodimetallic [LnLn'] Lanthanide Complexes: Towards a Chemical Design of 2-Qubit Molecular Spin Quantum Gates. *Journal of the American Chemical Society* 136 (2014), 14215.
- M. Castro, O. Roubeau, L. Piñeiro-López, J.A. Real, J.A. Rodríguez-Velamazán. Pulsed-Laser switching in the bistable domain of a cooperative spin crossover compound: a critical study through calorimetry. *Journal of Physical Chemistry C* 119 (2015), 17334.
- S. Gómez-De Pedro, D. Lopes, S. Miltsov, D. Izquierdo, J. Alonso-Chamarro, M. Puyol. Optical microfluidic system based on ionophore modified gold nanoparticles for the continuous monitoring of mercuric ion. *Sensors and Actuators B-Chemical* 194 (2014), 19-26.
- E. Imaz, R. Alonso, C. Heras, I. Salinas, E. Carretero, C. Carretero. Infrared thermometry system for temperature measurement in induction heating appliance *IEEE Transactions on Industrial Electronics* 61 (2014), 2622-2630.
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- J. Mateo Gascón, M.A. Losada Binué, A. López Lucía. POF misalignment model based on the calculation of the radiation pattern using the Hankel transform. *Optics Express* 23 (2015), 8061-8072.
- M. Gutierrez-Roig, C. Gracia-Lazaro, J. Perello, Y. Moreno, A. Sanchez. Behavioral transition with age in social dilemmas: From reciprocal youth to persistent response in "adulthood". *Nature Communications* 5 (2014), 4362,
- R. Tapia-Rojo, J.J. Mazo, J.A. Hernandez, M.L. Peleato, M.F. Fillat, F. Falo. Mesoscopic model and free energy landscape for protein-DNA binding sites: analysis of Cyanobacterial promoters. *PLoS Computational Biology* 10 (2014), e1003835.
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- J. Royes, C. Provenzano, P. Pagliusi, R.M. Tejedor, M. Piñol, L. Oriol. A bifunctional amorphous polymer exhibiting equal linear and circular photoinduced birefringences. *Macromolecular Rapid Communications* 35 (2014), 1890-1895.
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- D. Antolin; N. Medrano-Marques; B. Calv; P. Martinez, P. A Compact Energy Harvesting System for Outdoor Wireless Sensor Nodes Based on a Low-Cost In Situ Photovoltaic Panel Characterization-Modelling Unit. *Sensors* 17-8 (2017)
- C. Azcona, B. Calvo, N. Medrano-Marques, S. Celma, S. 1.2 V-0.18-1um CMOS temperature sensors with quasi-digital output for portable systems. *IEEE Transactions on the Instrumentation and Measurement* (2015).
- C. Gimeno, E. Guerrero, C. Sanchez-Azqueta, G. Royo, C. Aldea, S. Celma. Continuous-time linear equalizer for multigigabit transmission through SI-POF in factory area networks. *IEEE Transactions on Industrial Electronics* (2015).
- C. Gimeno, C. Sanchez-Azqueta, E. Guerrero, J. Aguirre, C. Aldea, S. Celma. Single-chip receiver for 1.25 Gb/s Over 50-m SI-POF. *IEEE Photonics Technology Letters* (2015)
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- N. Vinyoles, A. Serenelli, F.L. Villante, S. Basu, J. Redondo, J. Isern. New axion and hidden photon constraints from a solar data global fit *Journal of Cosmology and Astroparticle Physics* 1510 (2015), 015.
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