Study Plan

School: Institute for Research and Advanced Training
Degree: Doctorate
Course: Earth and Space Sciences (cód. 243)

Specialization Physics of the Atmosphere and Climate

1st Year - 1st Semester
Specialization Physics of the Atmosphere and Climate

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS09015D	Observation Techniques, acquisitionanddata Processing	*** TRANSLATE ME: Física da Terra e do Espaço ***Geology	4	Semester	104
FIS09016D	Seminars on Earth an Space Sciences	*** TRANSLATE ME: Física da Terra e do Espaço ***Geology	4	Semester	104

1st Year - 1st Semester
Specialization Physics of the Atmosphere and Climate

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Group of Options					

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS09017D	Remote Sensingand Atmospheric Aerosols and Clouds Modelling	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09018D	Atmospheric Modelling	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09019D	Obsertational Tecchniques, Instrumentation Modelling of Atmopheric Trace Gases	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09020D	Modelling of the Planetary Atmosphere Dynamics	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09021D	Climateand Climate Change	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09022D	Paleoclimate	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09023D	Complexflow Structures of Earth Fluids	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09024D	Atmospheric Electricity	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09025D	Resources, Energy and Environment	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09026D	Techniques of Imageand Digital Data Processing in Earth and Planetary Sciences	Physics *** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
*** TRANSLATE ME:Optativa livre ***					

Thesis

1st Year - 2nd Semester
Specialization Physics of the Atmosphere and Climate

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

2nd Year - 3rd Semester
Specialization Physics of the Atmosphere and Climate

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

2nd Year - 4th Semester
Specialization Physics of the Atmosphere and Climate

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

3rd Year - 5th Semester
Specialization Physics of the Atmosphere and Climate

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

3rd Year - 6th Semester
Specialization Physics of the Atmosphere and Climate

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

4th Year - 13rd Quarter
Specialization Physics of the Atmosphere and Climate

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

Conditions for obtaining the Degree:

*** TRANSLATE ME: Para aprovação na componente curricular nesta especialização deste programa de doutoramento é necessário a aprovação (através de avaliação ou creditação) das seguintes unidades curriculares:{\}newline

1º Semestre: {\}newline

- 2 UC Obrigatórias num total de 8 ECTS {\}newline

- 2 UC Optativas num total de 8 ECTS do conjunto de optativas disponíveis no plano de estudos desta especialização.{\}newline

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Para obtenção do grau, é necessário a aprovação na tese num total de 180 ECTS {\}newline

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Specialization Geophysics

1st Year - 1st Semester
Specialization Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS09015D	Observation Techniques, acquisitionanddata Processing	*** TRANSLATE ME: Física da Terra e do Espaço ***Geology	4	Semester	104
FIS09016D	Seminars on Earth an Space Sciences	*** TRANSLATE ME: Física da Terra e do Espaço ***Geology	4	Semester	104

1st Year - 1st Semester
Specialization Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Group of Options					

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS09027D	Earthquake Source	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09028D	Strong Motion Modelling	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09029D	Crustal Deformation Modelling	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09026D	Techniques of Imageand Digital Data Processing in Earth and Planetary Sciences	Physics *** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09031D	Rhelogie of the Earth	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09032D	Phenomena of Energy Transfer in the Earth	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09033D	Geomagnestism	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
*** TRANSLATE ME:Optativa livre ***					

Thesis

1st Year - 2nd Semester
Specialization Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

2nd Year - 3rd Semester
Specialization Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

2nd Year - 4th Semester
Specialization Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

3rd Year - 5th Semester
Specialization Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

3rd Year - 6th Semester
Specialization Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

4th Year - 13rd Quarter
Specialization Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
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Specialization Geological Processes

1st Year - 1st Semester
Specialization Geological Processes

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS09015D	Observation Techniques, acquisitionanddata Processing	*** TRANSLATE ME: Física da Terra e do Espaço ***Geology	4	Semester	104
FIS09016D	Seminars on Earth an Space Sciences	*** TRANSLATE ME: Física da Terra e do Espaço ***Geology	4	Semester	104

1st Year - 1st Semester
Specialization Geological Processes

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Group of Options					

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
GEO09034D	orogenic processes	Geology	4	Semester	104
GEO09035D	transpressive schemes; kinematics to dynamics	Geology	4	Semester	104
GEO09036D	Isotopes Unconventional	Geology	4	Semester	104
GEO09037D	Micro-analytical techniques in Earth Sciences	Geology	4	Semester	104
FIS09029D	Crustal Deformation Modelling	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09039D	Seismotectonics	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09031D	Rhelogie of the Earth	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
GEO09040D	Geochronology in orogenic processes	Geology	4	Semester	104
*** TRANSLATE ME:Optativa livre ***					

Thesis

1st Year - 2nd Semester
Specialization Geological Processes

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

2nd Year - 3rd Semester
Specialization Geological Processes

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

2nd Year - 4th Semester
Specialization Geological Processes

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

3rd Year - 5th Semester
Specialization Geological Processes

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

3rd Year - 6th Semester
Specialization Geological Processes

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

4th Year - 13rd Quarter
Specialization Geological Processes

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

Conditions for obtaining the Degree:

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Specialization Astronomy and Astrophysics

1st Year - 1st Semester
Specialization Astronomy and Astrophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS09015D	Observation Techniques, acquisitionanddata Processing	*** TRANSLATE ME: Física da Terra e do Espaço ***Geology	4	Semester	104
FIS09016D	Seminars on Earth an Space Sciences	*** TRANSLATE ME: Física da Terra e do Espaço ***Geology	4	Semester	104

1st Year - 1st Semester
Specialization Astronomy and Astrophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Group of Options					

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS09041D	Observacional Astrophysics	Physics	4	Semester	104
FIS09042D	Planetary Atmospheres	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09043D	Observational Techniques and Instrumentation in Astropysics	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09044D	Helioseismology	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09045D	Astroparticles	Physics	4	Semester	104
FIS09046D	Dynamic Computational Astropysics	Physics	4	Semester	104
FIS09047D	Space Weather	*** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
FIS09026D	Techniques of Imageand Digital Data Processing in Earth and Planetary Sciences	Physics *** TRANSLATE ME: Física da Terra e do Espaço ***	4	Semester	104
*** TRANSLATE ME:Optativa livre ***					

Thesis

1st Year - 2nd Semester
Specialization Astronomy and Astrophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

2nd Year - 3rd Semester
Specialization Astronomy and Astrophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
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Specialization Astronomy and Astrophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

3rd Year - 5th Semester
Specialization Astronomy and Astrophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

3rd Year - 6th Semester
Specialization Astronomy and Astrophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

4th Year - 13rd Quarter
Specialization Astronomy and Astrophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Thesis					

Conditions for obtaining the Degree:

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Para obtenção do grau, é necessário a aprovação na tese num total de 180 ECTS ***

Conditions for obtaining the Degree:

*** TRANSLATE ME: Área de Especialização em Física da Atmosfera e do Clima:{\}newline

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Para aprovação na componente curricular nesta especialização deste programa de doutoramento é necessário a aprovação (através de avaliação ou creditação) das seguintes unidades curriculares:{\}newline

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1º Semestre: {\}newline

- 2 UC Obrigatórias num total de 8 ECTS {\}newline

- 2 UC Optativas num total de 8 ECTS do conjunto de optativas disponíveis no plano de estudos desta especialização.{\}newline

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Para obtenção do grau, é necessário a aprovação na tese num total de 180 ECTS{\}newline

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Area de Especialização em Geofísica:{\}newline

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Para aprovação na componente curricular nesta especialização deste programa de doutoramento é necessário a aprovação (através de avaliação ou creditação) das seguintes unidades curriculares:{\}newline

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1º Semestre: {\}newline

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Para obtenção do grau, é necessário a aprovação na tese num total de 180 ECTS {\}newline

{\}newline

Área de Especialização em Processos Geológicos:{\}newline

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Para aprovação na componente curricular nesta especialização deste programa de doutoramento é necessário a aprovação (através de avaliação ou creditação) das seguintes unidades curriculares:{\}newline

{\}newline

1º Semestre: {\}newline

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Para obtenção do grau, é necessário a aprovação na tese num total de 180 ECTS {\}newline

Program Contents

Back

Observation Techniques, acquisitionanddata Processing (FIS09015D)

Back

Seminars on Earth an Space Sciences (FIS09016D)

Back

Remote Sensingand Atmospheric Aerosols and Clouds Modelling (FIS09017D)

Instrumentation used in remote sensing. Satellite systems. General Physical Principles of Remote Sensing in active and passive systems. Radiative transfer in the atmosphere applied to remote sensing. Study of various instruments and observation techniques for aerosols and clouds in the atmosphere. Notions of modeling of key atmospheric constituents.

Inversion problem in remote sensing. Inversion techniques. Applications to aerosols and clouds. Problems associated with validation.

Back

Atmospheric Modelling (FIS09018D)

Scales of motions and types of atmospheric models: LES, mesoscale, weather forecast and general circulation models.

The governing equations. Coordinate systems and projections.

Numerical methods and computational concepts. Discretization of the dynamic equations and parameterization of subgrid-scale physical processes.

Atmosphere-surface interactions and Boundary Layer representations. turbulence

Radiative transfer schemes. Clouds and precipitation. Shallow and deep convection. Atmospheric chemistry and aerosols parameterizations.

Data assimilation and model initialization.

Performing numerical simulations with atmospheric models: case studies

Back

Obsertational Tecchniques, Instrumentation Modelling of Atmopheric Trace Gases (FIS09019D)

Fundamental of stratospheric and tropospheric trace gases and atmospheric chemistry. Fundamental of geometrical optics. Spectrometers. DOAS method. Radiative transfer modeling. Inversion techniques for trace gas vertical profiling. Numerical and atmospheric chemistry modeling.

Back

Modelling of the Planetary Atmosphere Dynamics (FIS09020D)

(1) The Solar System, the planets and their atmospheres. (2) Origin and evolution of planetary atmospheres. (3) Observations of planetary atmospheres. (4) Energy balance and entropy. (5) Atmospheric temperature structure. (6) Atmospheric composition and chemistry. (7) Clouds, aerosols and dust. (8) Dynamics of planetary atmospheres. (9) Climactic change.

Back

Climateand Climate Change (FIS09021D)

Back

Paleoclimate (FIS09022D)

I. Thermal state of the Earth: heat transfer and heat generation in the Earth; heat flux in the Earth. The heat conduction equation.
II. Thermal properties of the earth materials: thermal conductivity and thermal diffusivity. Earth's radioactivity.
III. Thermal regime of the upper crust. Interaction of the atmosphere with the ground: air-ground coupling. Geothermal climate change observatory.
IV. Ground surface temperature reconstructions and interpretation. The concept and use of the reduced temperature. Advantages and limitations of the geothermal method for past climate reconstructions.

Back

Complexflow Structures of Earth Fluids (FIS09023D)

- Flows between volume (surface) to point and point to volume (surface). Competing regimes. Fluid trees.
- Constructal theory. Flow optimization under local constraints. Structure of fluid trees
- Scaling laws. Hierarchy of scales Fractal description. Fractals and dynamics.

Application: River basins; flow through porous media (sub-soil); convective boundary layer; convection at planetary scale.

Back

Atmospheric Electricity (FIS09024D)

- Solar and cosmic radiation, natural and artificial radioactivity and inductive ionization.Free charge generation in the Atmosphere. Charges, electric fields and currents in the low and upper Atmosphere.
- Planetary electric circuit. The ionosphere. The local atmospheric electric field (AEF) at ground level. Planetary influences upon the AEF.
- Fair weather electric current, and precipitation, convection, discharge and Maxwell electric current components.
- Interaction of the AEF with the local meteorological conditions. The influences of vapour content, nebulosity and cloud type, and wind field, on the atmospheric electric field. Interaction with aerosols.
- Electric phenomena in the troposphere: generation and growth of storm clouds, corona discharges and lightning strikes.
- Planetary electric phenomena: The Ionosphere, Schumann resonances and propagation of radio-electric and microwaves.

Back

Resources, Energy and Environment (FIS09025D)

- The climate system and environmental fluxes. Solar energy and planetary mechanical energy (wind, wave and hydropower energies). Photosynthesis and biomass. Potentialities and limitations for renewable energy and matter flows use.
- Mineral resources in the crust and the ocean. Amounts and types of mineral sources. Prospecting and discovery; quantification and time evolution of resources availability. Mineral extraction and processing; environmental impacts. Nature as source and sink of all fluxes; fluxes of energy and matter in the geosphere. Life-cycle analysis of economic activities.

Back

Techniques of Imageand Digital Data Processing in Earth and Planetary Sciences (FIS09026D)

1. Digital image fundamentals; image representation and enhancement
2. Image restoration, compression and segmentation
3. Object recognition
4. Analysis of discrete and continues time series;
5. Applications of multivariate analysis to geophysics;
6. Principles and techniques of signal treatment geophysics;
7. Fast Fourier Transforms (FFT), Z transforms Laplace transforms;
8. Deconvolution
9. Filter design and transfer function;
10. Spectral analysis.

11 Applications.

Back

Earthquake Source (FIS09027D)

Representation theorem. Far-field and near-field displacement. Focal parameters of earthquakes.. The source mechanisms. The seismic tensor moment. Scaling laws for earthquakes. Spectral and temporal radiation pattern. Seismic source dimension and stress drop. Fracture models. Seismic waves modeling. Finite and extended source models. Source time function and slip distribution. Dynamic Rupture models.

Back

Strong Motion Modelling (FIS09028D)

- Complements of Seismic Wave Propagation in Elastic Media
- Modelling of seismic responses of layered media.
- Modelling of seismic responses of 2D and 3D media.
- Large scale seismic waveform modelling.
- Strong ground motion modelling.
- Sources rupture process interpretation using seismic waveform data.
- Multi-scale seismic imaging of Earth interior.

Back

Crustal Deformation Modelling (FIS09029D)

Analysis of the main models that explain the crustal deformation;
Seismic cycle and their stages of deformation (pre seismic, co-seismic, post-sísmic and intersísmica);
Modelling co-seismic deformation by application of numerical and analytical techniques: Okada formula and theorem of representation arising;
Evaluate rupture models, by comparison of the inelastic synthetic displacement, with corresponding registered by geodetic techniques (GPS and DInSAR).
Application of crustal deformation models for the study of the dynamics of active regions.

Back

Rhelogie of the Earth (FIS09031D)

I. Introduction to the concepts of rheology. Rheology of continua: elasticity, stress, deformationand strain. Strength, fracture and plasticity.
II. Rheology of the lithosphere: fundamental equations; time effects and non-linearity; brittleness and plasticity; temperature in the lithosphere; rheological profiles (strength envelopes).
III. Rheology of the mantle: Physical parameters and composition of the mantle; rheology of the mantle from geophysical observables; thermal convection in the mantle; mantle rheology from microphysics.

Back

Phenomena of Energy Transfer in the Earth (FIS09032D)

I. Thermal state of the Earth: heat transfer and heat generation in the Earth; heat flux in the Earth.
II. Thermal properties of the earth materials. Earth's radioactivity.
III. Thermal regime of the lithosphere.
IV. Thermal regime of the mantle: thermodynamics of convection; thermal history and behaviour of the mantle; convective regime of the mantle.

Back

Geomagnestism (FIS09033D)

I. Earth's magnetic field: review of basic magnetism, magnetic materials, declination, inclination, intensity, isomagnetic charts.
II. Internal field, secular variation, reversals; External field, magnetosphere morphology. Spherical harmonics, International Geomagnetic Reference Field; Geocentric Axial Dipole, Non-dipole field. Selfreversal versus field reversal. Geomagnetic polarity timescale; reversal statistics; transitions.
III. Palaeomagnetism: Longevity of the geomagnetic field, Polarity reversals, Plate tectonics, Magnetoclimatology.
IV. Current problems: Polarity transitions, excursions, biomagnetism and micromagnetics.

Back

orogenic processes (GEO09034D)

Lectures (20h):
1 - Introduction / revisions:
a) Wilson cycle concept; Origin and general characteristics of intra-continental rifts and passive continental margins; Oceanic ridges and abyssal plains; Subduction zones, island arcs and active continental margins; Sedimentary basins in compressive regimes; Terranes.
2- General structure of orogenic belts.
3 - Young orogens
3.1 - Convergence Ocean-continent, the example of the Andes
3.2 - continental collision, the example of the Himalayas
3.3 - Arc-continent collision, the example Timor
4 - Precambrian tectonics
4.1 - Archean tectonics
4.2 - Proterozoic tectonics
5 - The Variscan Orogeny based on the Geology of the Iberian Peninsula: Structure and geodynamic evolution of the Iberian Massif.
Practical classes (10h):
Analysis and interpretation of geological maps of the Iberian Massif at various scales.
Field classes (30h):
Geological traverse between Portalegre and Pomarão.

Back

transpressive schemes; kinematics to dynamics (GEO09035D)

The inevitability of transpression / transtension.
1. Transpressive regimes; genesis, characteristics and variability
3. Numerical modelling; from the boundary conditions to the strain ellipsoids.
3. Folding mechanisms; from the classical models to the interaction of mechanisms.
4. Strain partitioning and decoupling;
4.1 the role of anisotropies
4.2 the diversity of solutions in strain partitioning
4.3 analogical modelling
5. Discussion of classical examples
5.1 Sumatra
5.2 New Zealand
5.3 San Andreas Fault
5.4. the Iberian variscides
6. Interpretation of new situations

Back

Isotopes Unconventional (GEO09036D)

1. Terrestrial cosmogenic nuclides: 3He, 10Be, 21Ne, 26Al, 36Cl, 53Mn;
1.1. Sources, production rates and scaling and correction factors;
1.2. Application on geological surface processes;
2. Isotopes of transition metals: the case of Fe, Cu, Zn;
2.1. Application on environment and archaeometry;
3. Sampling strategies;
4. Analytical methods of non-conventional isotopes: AMS and MC-ICP-MS;
5. Data interpretation and sources of error.

Back

Micro-analytical techniques in Earth Sciences (GEO09037D)

Back

Seismotectonics (FIS09039D)

Back

Geochronology in orogenic processes (GEO09040D)

Zircon characterization and isotopic system U-Th-Pb.
Methodology of sample preparation for the extraction of zircon (sampling, grinding, magnetic separation by density and optical observation). Transmitted light microscopy studies and of cathodoluminescence for morphological characterization of zircon.
Using of SHRIMP (Sensitive High Resolution Ion Micro Probe) and of LA-ICP-MS zircon geochronology for zircon dating; Complementarity with other methods of geochronology of amphibole, garnet and mica.
Data processing and error calculations, Concord diagrams and Tera-Wasserburg.
Practical application examples to the natural interpretation of the temporal evolution of orogenic processes.

Back

Observacional Astrophysics (FIS09041D)

(1) Introducton to Celestal Mechanics. (2) Sky reference frames. (3) The electromagnetc spectrum. (4) Astrophysical bodies and phenomena. (5) Optcal Astronomy. (6) Fundamentals of Radioastronomy. (7) High Energy Astrophysics. (8) Interferometry. (9) Exploraton of the Solar System. (10) Introducton to astronomical data. (11) Observatories. (12) Data reducton.

Back

Planetary Atmospheres (FIS09042D)

(1) The Solar System, the planets and their atmospheres. (2) Origin and evolution of planetary atmospheres. (3) Observations of planetary atmospheres. (4) Energy balance and entropy. (5) Atmospheric temperature structure. (6) Atmospheric composition and chemistry. (7) Clouds, aerosols and dust. (8) Dynamics of planetary atmospheres. (9) Climactic change.

Back

Observational Techniques and Instrumentation in Astropysics (FIS09043D)

(0) Overview on electromagnetism and propagation ; (1) Fundamentals of Radioastronomy; (2) Receivers and signal processing; (3) Fundamentals of Antenna theory; filled aperture antennas(4) Observational Methods; Earth Atmosphere; Calibration; homodinic and heterodinic systems; bolometers (5) Continuum Observational Strategies; point sources and extended sources; The Sun and the Milky Way (5) Emission mechanisms (continuum, thermal, non thermal); (6) Neutral Hydrogen lines; molecules in space (7) Current R&D in microwave projects. (8) The future: XXI century big interferometers and the space bolometer platforms.

Back

Helioseismology (FIS09044D)

Brief review of basic concepts of vector calculus; (1) Introduction to the study of stellar and solar oscillations; (2) Analysis of solar oscillations; (3) Equations of hydrodynamics and basic notions of MHD; (4) Equation of linear non-adiabatic non-radial oscillations; (5) Properties of solar and stellar oscillations; (6) Numerical Techniques; (7) asimptótica theory of stellar oscillations; (8) rotation and stellar oscillations; (9) inversion techniques in Helioseismology. (10) Excitation and decay of stellar oscillations. (11) Open problems in solar physics, present and future of solar observation missions.

Back

Astroparticles (FIS09045D)

Quarks, leptons, and their interactions. Interaction cross sections. The expanding universe. Radiation and nucleosyntesis in the early universe. Conservation laws and symmetries. Dark matter and dark energy. The spectrum and composition of cosmic radiation. Solar neutrinos. Nuclear and particle physics in stars.

Back

Dynamic Computational Astropysics (FIS09046D)

(1) Basic equatons of fuid dynamics. (2) Simple models of astrophysical fuids and their movements. (3) Theory of bodies in rotaton. (4) Dynamical instabilites of fuids. (5) Magnetohidrodynamics of fuids. (6) Computatonal techniques. (7) Dynamics of planetary atmospheres. (8) Accreton, winds and shocks. (9) Jeans instability and stellar formaton. (10) Stellar oscillatons. (11) Helio-seismology.

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Space Weather (FIS09047D)

(1) Introduction to space weather: brief history, its impact on society. (2) The Sun: structure and dynamics. (3) The heliosphere: the corona and the solar wind, the interplanetary magnetic field, coronal mass ejection, cosmic rays. (4) The Earth's space environment: the magnetic field, interaction of the solar wind and magnetosphere. (5) The technological impacts of space storms: impacts on satellites, radio communication, navigation and ground systems. (6) The difficulties of living in space.