Advanced instrumentation for the study of nuclear structure and reaction dynamics
Francesco Recchia, Daniele Mengoni

In this course the detectors in use for contemporary nuclear physics experiments will be explained starting from the basics of the detector manufacturing, detection processes, signal formation and performance obtainable. Different kind of detectors and configurations will be discussed in particular solid state detectors, like silicon and germanium detectors, and magnetic separators and spectrometers. Their use will be illustrated with examples of real experiments, along with a description of radioactive ion beam facilities where these experiments could be performed.

Advanced Optical Fluorescence Microscopy in Biology
Mario Bortolozzi

Description: The foundations of modern light microscopy were established more than one century ago by Ernst Abbe. Starting in the late 1970s, advances in the spatial and temporal resolution of video microscopy brought about a revitalized interest in the power and use of the light microscope, especially in biology due to the exponential growth that are currently being witnessed in fluorescent protein and synthetic fluorophore technology. Live-cell imaging performed by optical fluorescence microscopy has now become a requisite analytical tool in most cell biology laboratories, as well as a routine methodology that is practiced in the wide ranging fields of neurobiology, developmental biology, and many other related biomedical research disciplines. This course aims to illustrate the physical foundations of the imaging techniques that, in the last five decades, have revolutionized the study of the complexity of cellular and molecular dynamics in living cells.

Programme: The course is subdivided into seven chapter: light propagation laws and lenses; fluorescence introduction: fluorescence image formation; confocal microscopy; multiphoton microscopy; super-resolution STED microscopy; Ca2+ dynamics in living cells.

An introduction to axion physics
Luca Di Luzio / Stefano Rigolin

The course provides a general overview on axion physics, touching different topics going from particle physics to astrophysics and cosmology, as well as axion detection concepts. It is aimed at a mixed audience of theory/experiment oriented students.
Axions in Particle Physics (12h)
QCD vacuum structure and the strong CP problem
Peccei Quinn mechanism (and other solutions)
Axion chiral potential (axion mass and coupling to photons)
Axion effective Lagrangian (Georgi-Kaplan-Randall basis)
Benchmark axion models (KSVZ/DFSZ)
Axion models beyond benchmarks

Axions in Astrophysics (4h)
Axion production mechanisms
Axion limits from Stellar Evolution

Axions in Cosmology (4h)
Axions as hot thermal relics
Axion Cold Dark Matter (misalignment and topological defects)

Axion detection (4h)
Axion Electrodynamics
Axion searches: Laboratory/Helioscopes/Haloscopes

Cosmology
Sabino Matarrese e Nicola Bartolo

The "Cosmology" course aims first of all at providing a concise introduction to the current research in this field, both in the direction of Early Universe physics and Inflation and in the context of the late Universe (large-scale structure formation, evolution and statistical analysis) as well as at the phenomenological characterization of dark matter and dark energy. Emphasis will be given to some of the most up-to-date issues nowadays in cosmology. According to the audience, a selected list of advanced topics can be presented, tuned to the interests of the students. During the course students will be encouraged to read at least one or two papers on some topics of particular interest and to report them with a brief interactive discussion with all the classmates.

CONTENTS:
Standard cosmology: Fundamentals of General Relativity for cosmology; Cosmological models; Friedmann-Robertson-Walker metric (2 hrs. - Matarrese)
Thermodynamics of the Universe: elements of kinetic theory in the expanding Universe; evolution of the entropy and of the main thermodynamical quantities; photon and neutrino decoupling; relic particles (4 hrs. - Matarrese)
Inflation: problems of the standard cosmological model; kinematics and dynamics of inflation models; generation of primordial perturbations and their effects on the Cosmic Microwave Background. (8 hrs. - Bartolo)
Gravitational Instability: linear evolution of perturbations; Jeans scale; free-streaming, models with dark matter and baryons; cold dark matter, hot dark matter, etc.. (4 hrs. - Matarrese)
Statistics of cosmological perturbations: power-spectrum; transfer function; filter functions; higher-order statistics (2 hrs. - Matarrese)
Non-linear evolution of perturbations: N-body techniques; spherical model; Zel'dovich approximation and adhesion theory. (2 hrs. - Matarrese)
Dark Energy: observational aspects; models. (2 hrs. - Matarrese)

A LIST OF POSSIBLE ADVANCED TOPICS:
Techniques for computing primordial non-Gaussianity
Open quantum systems in cosmology
Non-linear and general relativistic cosmological perturbations

BIBLIOGRAPHY
E.W. Kolb and M.S. Turner, 1990. The Early Universe, Addison-Wesley
Dark Matter Phenomenology  
Francesco D’Eramo, Ennio Salvioni  

Dark matter constitutes 85% of the matter content of the Universe, but its origin and composition remain unknown. This course will introduce two strongly motivated paradigms for the micro-physical description of dark matter, which drive the majority of current experimental efforts: WIMPs and axions. 

The first part of the course will focus on WIMPs, starting with the thermal freeze-out mechanism that determines their present-day abundance. Different particle physics realizations of freeze-out dynamics will be introduced. Then, the three main avenues to search for WIMPs will be presented: direct detection with laboratory experiments, indirect detection with ground- and space-based observatories, and dark matter production at particle accelerators. 

The second part of the course will focus on axions, starting with the non-thermal misalignment mechanism that sets their cosmic abundance. We will discuss aspects of axion cosmology (thermal production) and astrophysics (star cooling), which lead to important constraints on the scenario. Then, the three main classes of axion laboratory searches will be presented: halo-scopes, helio-scopes, and light-shining-through-wall experiments. 

Effective Field Theories for Particle Physics: Theoretical and experimental perspectives  
Ramona Grober and Paride Paradisi  

This course provides an introduction on the basic ideas and methods of effective field theories (EFTs) in particle physics which are relevant for making contact with experimental observations. The intuitive idea behind effective theories is that you can calculate without knowing the exact theory. (Engineers are able to design and build bridges without any knowledge of strong interactions or quantum gravity!) In some sense, the ideas of EFT are obvious. However, implementing them in a mathematically consistent way in an interacting quantum field theory (QFT) is not so obvious. These lectures provide pedagogical examples of how one actually implements EFT ideas in particle physics calculations of experimentally relevant quantities. The topics discussed include both formal and phenomenological aspects. 

Theory: relevant and irrelevant operators and scaling, renormalization in EFTs, decoupling of heavy particles, power counting, naive dimensional analysis (NDA). Fermi theory, EFT in the heavy-top limit. Chiral perturbation theory. Construction of the Standard Model Effective Field Theory (SMEFT) in different bases (Warsaw basis, SILH basis, HEFT) and their related power counting. 

Phenomenology: flavor structure of EFT operators under the ansatz of Minimal Flavor Violation and Partial Compositeness. Leptonic and hadronic observables with flavor changing and/or CP violation. The muon g-2 anomaly and the B-meson anomalies at LHCb. 


Elements of X-ray Physics  
Monaco Giulio, Maurizio Chiara, Peihao Sun  

Interaction of X-rays with matter; sources of X-rays;
refraction and reflection from interfaces;
kinematical diffraction;
X-ray imaging;
photoelectric absorption;
inelastic X-ray scattering;
resonant scattering.

Exploring the Universe with Gravitational Waves
Bertacca Daniele, Raccanelli Alvise, Ricciardone Angelo

The field of gravitational wave physics has grown rapidly after the LIGO/Virgo collaboration detected for the first time in 2015 gravitational waves emitted by the merger of a black hole binary system. Gravitational Waves are emitted not only by the merging of astrophysical compact objects (Black Holes, Neutron Stars, Core Collapse SN, etc) but also from early universe mechanisms, like inflation, phase transitions, etc.
In this course we will provide a broad and comprehensive training in both theory and experiments in gravitational wave physics: we will introduce what gravitational waves are, review the main astrophysical and cosmological sources, and how we can model and describe them. Then we will focus on the experimental challenge of detecting and measuring gravitational waves and review GW detectors (their operating principles, experimental techniques, key figures and noise budget), techniques of data analysis used to extract physics information, GW operation of a network of GW detectors and will summarize signals detected so far.

PROGRAM
Introduction to Gravitational Waves
Cosmological sources of GW and propagation of in curved spacetime
Astrophysical sources of GWs and their characterization
Interaction of gravitational waves with test masses and the principles of interferometric detection

-GW interferometers: working principle

GW interferometers: noise budget

GW detector network: open public alerts, sky localization

Information theory, inference and computation
Carlo Albert, Jeff Byers

Basic Principles
Bayesian Statistics: prior, likelihood, posterior.
The Monte Carlo Paradigm: noise vs. bias.
Basic building blocks of samplers: transformations, weighting (importance sampling), acceptance/rejection.
Exploring a high-dimensional potential
The Metropolis algorithm (Markov Chain Monte Carlo)
Gibbs sampling: local interactions.
Adaptive (non-Markov) algorithms
Ensemble methods
Information Theory
Information Bottleneck, and predictive information.

Diffusion and Information theory: Machine learning kernels and the Green’s function of the Diffusion equation

Partially Observed Markov Decision Processes

Example: application to time series data.

Bayesian inference: Letting the model fluctuate around the data

Gaussian Process (GP): Using a path integral to fit data

GP Example: Fitting spherical harmonics to data

GP Example: Guassian Process for Time Series

Dirichlet Process and Information Theory (DP): The probability over probability distributions

Example: Computing the uncertainty in the density estimation of a gas

Example: Unsupervised Clustering of data points

Information Geometry

Using Entropy to Understand Probability

Comparing probability distributions: From KL divergence to information geometry

Local structure versus Global symmetries: Hamiltonians or Green’s functions

The manifold of multivariate Gaussian probability distributions

Diffusion on a Manifold: Parametric approximation

The Estimation of the Gradient of a Density Function

Example: manifold learning from time series data.

Example: clustering data

The statistics of high-dimensional point clouds

Estimating the dimensionality of the data

Manifold Learning and Local Models in high dimension.

Mixture of Probabilistic PCA

Divide and conquer the manifold: Estimating tangent spaces in high-d data

Stitching together the tangent spaces: Interpolating between tangent spaces

Example: Application to data

Hamiltonian Dynamics: Beyond random search.

Hamiltonian Monte Carlo (HMC)

HMC for stochastic differential equations: path-integrals and separation of time.

Thermodynamics: Entropy and learning.

Approximate Bayesian Computation (ABC)

Simulated Annealing ABC: learning with minimal entropy production [Albert et al. 2014].


Statistical Mechanics: Interacting particle systems as inference tool.

Field-theoretic description: Doi-Peliti formalism.

Inference: particle filters and path-integral methods

Introduction to Bosonization in Condensed Matter Physics

Luca Dell’Anna

An elementary introduction to the technique of Bosonization for 1-dimensional systems and its relevant applications in Condensed Matter Physics are presented. The main topics of the course are the
following:
1) Fermi surface and spectrum of low energy excitations of free spinless fermions.
2) Green's functions of left and right moving Fermi fields.
3) Normal ordering and Tomonaga Hamiltonian.
4) Kac-Moody algebra as a spectrum generating algebra for Tomonaga Hamiltonian.
5) Application to an interacting fermionic system: the Luttinger liquid.
6) Application to a quantum spin chain: Bosonization of the Heisenberg model.
5) Spinful fermions: spin-charge separation and application to Fermi-Hubbard model.

Modern topics in statistical physics
Enrico Carlon, Christian Maes, Gianmaria Falasco

The course contains two parts.
The first one, by E. Carlon, covers the physical properties of biomolecules as DNA, including in particular mechanical features as the twist-stretch coupling.
In the second part, by C. Maes and G. Falasco, some recent developments in the field of nonequilibrium statistical mechanics are discussed. The focus is on entropy production, speed limits, and kinetic aspects that become relevant far from equilibrium in addition to dissipative ones.

Neutrino Physics
R. Brugnera, S. Dusini, M. Lattanzi

Neutrino oscillations (S. Dusini): Three flavours oscillations, PMNS matrix, neutrino oscillations in matter, solar neutrinos, atmospheric neutrinos, terrestrial neutrino oscillation experiments, global analysis of oscillation data, sterile neutrinos. Direct measurements of neutrino mass (R. Brugnera) Beta decay, pion and tau decays, neutrinoless double-beta decay Relic neutrinos (M. Lattanzi)

Nuclear reactions with heavy ions
Andrea Vitturi, Alberto Stefanini

In the first part of the course we will discuss the main features of nuclear reactions with heavy ions (elastic scattering, inelastic scattering, Coulomb excitation, break-up, transfer, deep inelastic), in particular in connection with the structural properties. Special attention will be given to reactions involving weakly-bound nuclei far from stability and close to the drip lines. The second part will be devoted to the description of sub-barrier fusion processes, from both experimental and theoretical points of view. The role of the coupling to the internal degrees of freedom of the interacting nuclei will be emphasized. Again the case of weakly-bound nuclei will be explicitly treated.

Nuclear structure and reaction dynamics with radioactive ion beams
Jose Javier Valiente Dobon (Laboratori Nazionali di Legnaro), Alessia Di Pietro, (Laboratori Nazionali del Sud)

This is an introductory course of 24 hours that can be followed by everybody with a master degree in Physics. The course is delivered (12 hours each) by dr. Di Pietro and dr. Valiente-Dobon. The course will discuss: i) introduction to nuclear structure that can be performed with large gamma spectrometers, more specifically with germanium and scintillator detectors and ii) introduction to nuclear reaction studies and experimental techniques and calculation tools to study reaction processes.
The evaluation will be based on: i) final colloquia about the topics discussed during the course and ii) preparation and discussion of an experiment (each student will choose one topic of interest) using RIB.
Physics at Future Colliders  
Patrizia Azzi

Basic introduction to collider physics. Description of future projects: e+e- machines (linear and circular), hadron machines (with heavy ion running), and muon collider. Description of different physics challenges (background, pileup) and ultimate performance. Goal of the course: understanding the advantages and limitations of the different machine choices for various physics benchmarks.

Quantum Effects in Gravity  
Luca Martucci, Stefano Massai, Marco Peloso

We do not have yet a complete theory of quantum gravity. Nonetheless, important advances have been obtained with a semiclassical approach in which quantum fields are quantized on a classical background. This course aims at proposing basic aspects and techniques for the quantization of fields on a curved spacetime, followed by several applications of physical relevance, both for black-holes physics and theoretical cosmology.


Program:

Part 1: Quantization

** Choice of the vacuum in quantum mechanics and in Quantum Field Theory (QFT) in Minkowski spacetime
** Choice (and ambiguity) of vacuum in curved spacetime; quantization

Part 2: Applications

** Warm up: Unruh effect
** Hawking effect
** Entropy and information paradox
** Superradiance
** Quantum fields in de Sitter
** Cosmological perturbations
** Gravitational production

Quantum Physics with atoms and ions  
Luca Salasnich

The course gives an introduction to quantum phenomena with atoms and ions (and also superconductors) which are currently under intensive investigations: Bose-Einstein condensation, topological quantum states, macroscopic quantum tunneling and Josephson effect, and BCS-BEC crossover. Both experimental and theoretical methods and techniques will be discussed and analyzed.

Program of the course

Bose-Einstein condensation with ultracold alkali-metal atoms (4 h).
Experimental trapping techniques for atoms and ions (4 h).
Topological states with ultracold atoms: quantized vortices and dark solitons. Bright solitons (4 h).
Superfluid hydrodynamics for bosons and fermions.
Macroscopic quantum tunneling and Josephson junctions (4 h).
Two-dimensional systems: topological phase transition of Kosterlitz-Thouless (2 h).
BCS theory for superconductors and fermionic atoms.
Ginzburg-Landau equation (2 h).
BCS-BEC crossover for atoms (4 h).

Suggested books:

Period: January 2023 - March 2023.
Exam: Seminar of the student on a specific topic of the course.

Quantum tools for future scientific research
Simone Montangero

Prerequisites: quantum mechanics

Quantum science stemmed from the revolutionary idea, push forward about thirty years ago by R. Feynman, to replace classical hardware with quantum hardware to attack one of the most complex problems in physics, i.e., the quantum many-body problem. Nowadays, quantum science is a fast developing field encompassing tools and concepts from condensed matter, quantum optics, theoretical physics, and information theory. Quickly it has become evident that this new paradigm could lead to a complete novel technology that could be used both for scientific and practical applications. Currently, there is a fast-growing zoo of possible novel research directions opened by this new class of tools. This course aims to introduce the student to this new area of research. We will quickly review the basics of quantum information theory and some of the most promising applications of quantum technologies for future research. In particular, we will present the achievements and the challenges obtained by quantum simulators, dedicated quantum hardware built to simulate interesting but hardly accessible physics: from models to study for high-Tc superconductors or topological systems, critical systems, quantum chemistry or lattice gauge theories where Monte Carlo methods efficiency is hindered by the sign problem. Finally, we will review the first quantum computations and quantum simulations and their possible applications in quantum chemistry, computer science, nuclear physics, and high-energy physics. Connections with the IBM quantum cloud service and didactic program will be explored. The course will have a hybrid structure, with frontal lessons and seminars held by the students to present the most recent quantum simulators applications.
Renormalization group in statistical mechanics
Amos Maritan

Critical phenomena are characterized by diverging length-scales that manifest with the emergence of correlation functions decaying as power laws both at large spatial and temporal distances and more in general by the presence of singularities in the free energy in the thermodynamic limit. This implies that a macroscopic system close to or at criticality cannot be understood in terms of the properties its finite subparts. The renormalization group technique can explain, in a very general setting, the emergence of singularities in the thermodynamic limit using an iterative procedure involving only analytic recursion equation. The goal of this set of lectures is to present the general formalism underlying the renormalization group technique followed by several applications to paradigmatic examples both in real space and in momentum space within field theoretical models.

Scattering Amplitudes for Gravitational Waves Physics: the EFT approach
P. Mastrolia, M. Mandal

1. Introduction to Effective Field Theory approach to General Relativity.
2. Feynman rules for matter-graviton scattering.
3. Modern techniques for Feynman calculus.
4. Applications to coalescing binary systems and gravitational waves physics

Statistical data analysis
Denis Bastieri, Tommaso Dorigo, Luca Stanco

General Introduction:
Random variables, probability density functions, the Central Limit theorem, cumulative function, properties of estimators, examples and applications.
Methods of minimum squares and maximum likelihood, covariance matrix. Applications and examples.
Error propagation: some examples and practical applications.
Probability theory, Kolmogorov axioms, theorem of Bayes, practical applications.
Interval estimation, confidence intervals, hypothesis testing and p-values, goodness of fit and practical applications. Construction of the power-curve. Coverage for the confidence intervals from maximum likelihood.
The problem of the measurement of 0 or very few events. The method of Feldman-Cousins.
Technicalities in the generation of random numbers. Simulations of several functional relations.
Statistics in HEP:
Evaluation of p-values for counting experiments, with and without nuisances.
Definition and computation of significance for a signal.
Correspondence between p-value and significance in case of non-Gaussian nuisances.
Look-elsewhere effect and approximate methods for its estimation.
The CLS method and its application to the search for signals.
Profile likelihood and statistical tests.
Application to the search for the Higgs boson at LHC.
Asymptotic methods for the evaluation of sensitivity with the profile likelihood.
Use of the Feldman-Cousins method for exclusion plots.
Statistics in Astrophysics:
Applications of statistical inference and test of models: Z-score and T-score
Coefficient of correlation and related test. Bootstrapping.
Non-parametric tests: Spearman’s rank.
Kolmogorov-Smirnov: test and related applications, test of Cramér-von Mises
Test of isotropy: monopole, dipole and quadrupole, statistics of Rayleigh, Watson and Bingham.
Correction of Bonferroni or trial factors.
Test of Anderson-Darling.
Statistics of Cash (Poisson)
Application of maximum likelihood: the catalogue.
Errors of type I and type II: screening and testing, technicalities, sensitivity and power of testing.
Data analysis: correlation, auto-correlation, function of angular correlation at 2 points, and applications.
Analysis of images: linear filters and applications, the Gaussian filter
General Introduction:
Random variables, probability density functions, the Central Limit theorem, cumulative function, properties of estimators, examples and applications.
Methods of minimum squares and maximum likelihood, covariance matrix. Applications and examples.
Error propagation: some examples and practical applications.
Probability theory, Kolmogorov axioms, theorem of Bayes, practical applications.
Interval estimation, confidence intervals, hypothesis testing and p-values, goodness of fit and practical applications. Construction of the power-curve. Coverage for the confidence intervals from maximum likelihood.
The problem of the measurement of 0 or very few events. The method of Feldman-Cousins.
Technicalities in the generation of random numbers. Simulations of several functional relations.
Statistics in HEP:
Evaluation of p-values for counting experiments, with and without nuisances.
Definition and computation of significance for a signal.
Correspondence between p-value and significance in case of non-Gaussian nuisances.
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Profile likelihood and statistical tests.
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Coefficient of correlation and related test. Bootstrapping.
Non-parametric tests: Spearman’s rank.
Kolmogorov-Smirnov: test and related applications, test of Cramér-von Mises
Test of isotropy: monopole, dipole and quadrupole, statistics of Rayleigh, Watson and Bingham.
Correction of Bonferroni or trial factors.
Test of Anderson-Darling.
Statistics of Cash (Poisson)
Application of maximum likelihood: the catalogue.
Errors of type I and type II: screening and testing, technicalities, sensitivity and power of testing.
Data analysis: correlation, auto-correlation, function of angular correlation at 2 points, and applications.
Analysis of images: linear filters and applications, the Gaussian filter

String Theory
Stefano Massai, Luca Martucci

String Theory is a theory of quantum gravity which is currently the best candidate for a UV completion of the presently tested models of the fundamental interactions. It can be used to answer questions sensitive to the Plank scale; it provides a set of lower energy effective field theories which are relevant for phenomenology, putting constraints on models of cosmology and particle physics beyond the standard model. It has produced several ground-breaking results: the explanation of the microscopic origin of the Bekenstein-Hawking entropy of black holes, the AdS/CFT correspondence (that is, the holographic description of strongly coupled quantum field theories), the discovery of large families of non-perturbative “dualities” between apparently unrelated quantum theories, and many others. Such developments are by now standard toolkits in diverse research areas. The aim of this course is to explain the basic principles of String Theory and it is addressed to any student who would like to enlarge her/his general knowledge of the physics of the fundamental interactions. The program will be the following:

Part 1 (Massai, 12h) - Introduction to perturbative string theory
classical actions for the bosonic string;
quantisation of the bosonic string and its spectrum;
extension to the superstring.

Part 2 (Martucci, 12h) - Superstring effective actions and dualities
string theory effective actions;
D-branes and other extended objects;
dualities.

Structured light: from principles to modern applications
Gianluca Ruffato, Filippo Romanato

A beam of light holds many properties such as the intensity value and pattern, polarization (denoting spin angular momentum), wavelength (linear momentum), and orbital angular momentum (associated with its phase structure). Structured light refers to the users’ ability to engineer the aforementioned degrees of freedom, individually or in combination, in order to enhance or extend their optical capabilities. In the last decade, the possibility to modify and control the intensity and phase distribution of light has fostered this new flourishing research framework, showing disrupting and powerful applications in a wide range of fields, encompassing particle manipulation and tweezing, microscopy, imaging, classical and quantum communications. The course will introduce to the basic and advanced tools that are necessary to understand and describe the generation, propagation and manipulation of
structured light beams, focusing in particular on optical beams carrying orbital angular momentum. The methods to control and detect this unexploited degree of freedom of photons will be presented in the light of cutting-edge applications in classical and quantum telecommunications both in free-space and through optical fibres, describing also how this novel optical framework is associated with a new paradigm in optical elements design, the so-called metasurfaces. Experimental demonstrations will be done in order to apply the fundamental concepts to specific cases of interest. A significant part of the course will be devoted also to introduce the nanofabrication techniques and protocols to fabricate the state-of-the-art optical elements required to generate and control structured light beams.

Supersymmetry and Supergravity
Davide Cassani, Gianguido Dall'Agata

The course provides an introduction to supersymmetric quantum field theory and supergravity. The basic formalism will be illustrated, starting from the supersymmetry algebra, its representations and the construction of invariant Lagrangians. The superfield formalism and holomorphicity will be used to prove important non-renormalization theorems. Gauging the supersymmetry will lead us to introduce the gravitino field and construct supergravity Lagrangians. As applications, we will discuss various mechanisms for susy breaking and low-energy effective actions. Depending on the background of the students, more advanced topics may also be considered.

SOFT SKILLS:

Communicating science and its history
Giulio Peruzzi, Sofia Talas, Taha Arslan (Istanbul University), Silke Ackerman (Oxford University)

The main objective of the course is to provide students with knowledge, ideas and tools to communicate science and its history to the public. The course will examine on the one hand scientific research and teaching practices from the Islamic world to today’s Europe, and it will present on the other hand some current techniques of science communication and public engagement. After the course, students should be able to:
explain and discuss different approaches to communicate science and its history;
look for and critically discuss primary and secondary sources in the history of science;
design new projects of science communication.

The course is part of the third-mission project of the DFA for 2022-2023, entitled “Science from the Islamic world to today's Europe - Cross-fertilisation between past and future”, which aims at shedding light on the cross-fertilisation of science brought by the interactions between various countries and cultures. The project is based on the co-creation of knowledge by the local communities and the public, and it will involve PhD students of the Department of Physics and Astronomy, and members of Padua foreign communities, in particular Muslim communities. During the course, students will thus have the challenging opportunity of working in groups, with people of various nationalities and different backgrounds, which is a great opportunity of sharing knowledge and experiences.
EU funding: opportunities for Research and Innovation and proposal writing
Manuela Schisani

The course aims to introduce to the European strategies and the funding opportunities regarding Research and Innovation for the next years. The participants will acquire the skills to identify the most appropriate forms of access to EU funds, and will enhance their knowledge on effectively writing projects for applying to the calls for proposal. How to write properly a CV for EU projects will be also discussed.

Teaching and Learning Physics at University
Ornella Pantano, Marta Carli

The course provides PhD students with some key ideas and tools useful to understand how to facilitate the learning of physics and how to set up effective teaching. The main themes and issues from physics education research will be discussed, such as students' difficulties and resources, laboratory teaching and learning, and physics problem solving. Participants will engage in discussions about research papers and in collaborative activities. As the final output of the course, participants will develop their own project work focusing on a topic in introductory physics.