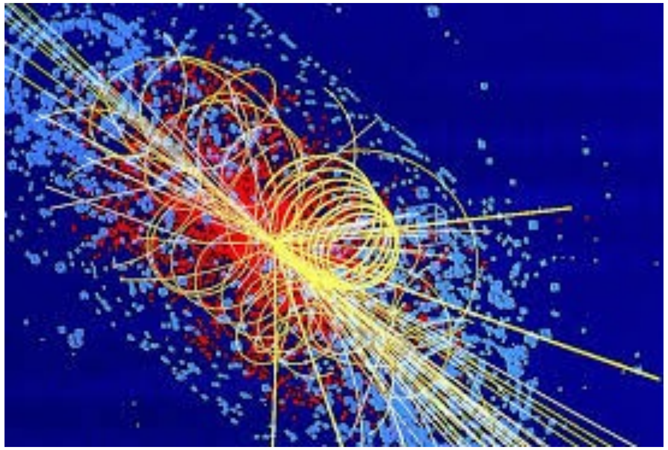

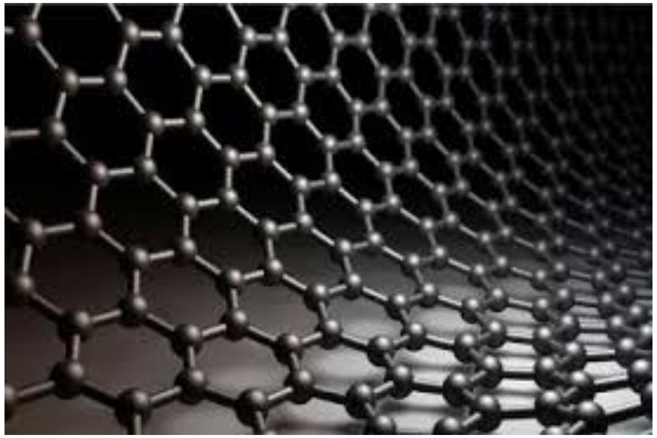

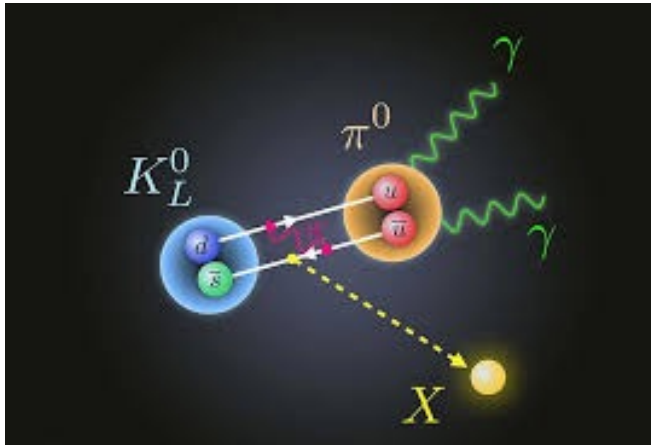

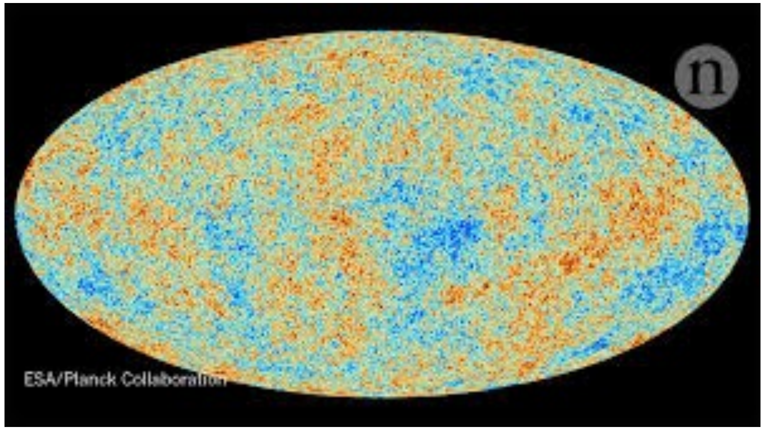

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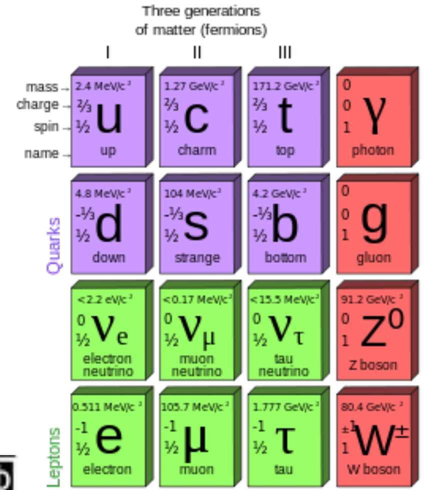

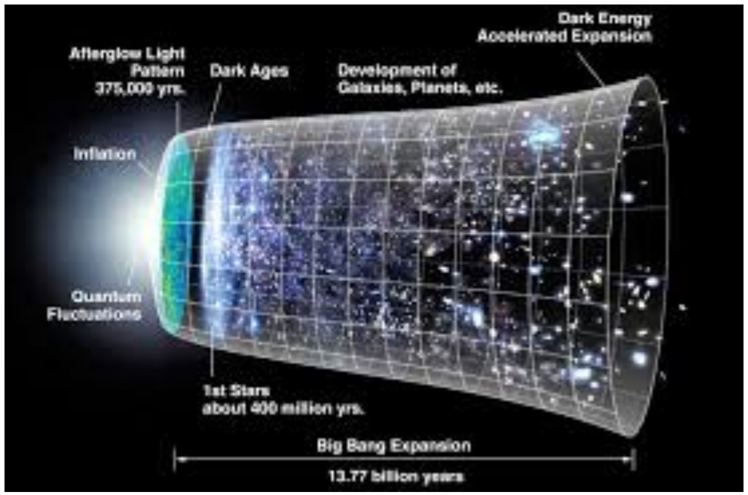

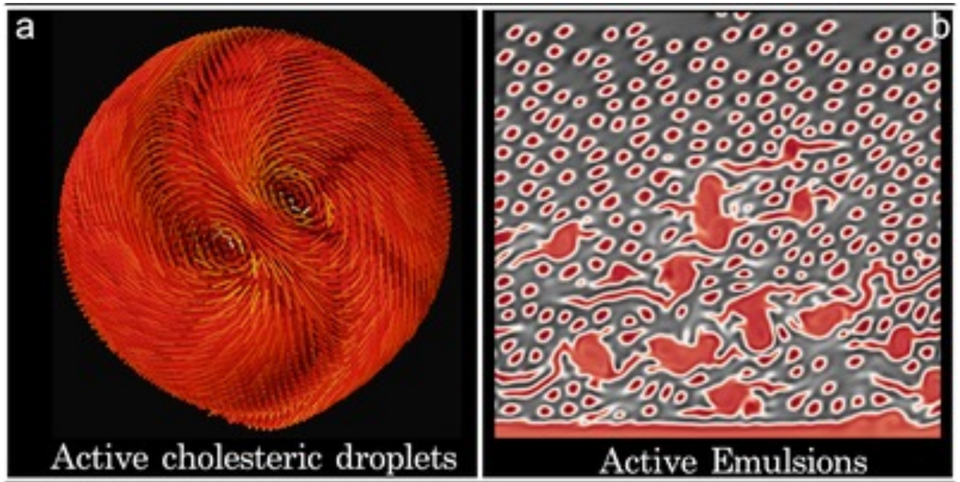

SUPRA
(Southern Universities Physics Research Agreement)

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I. Particle Detectors–Trigger/DAQ

Module 1	Particle Detectors
Lecturer	Margherita Primavera (INFN Lecce)
Planned hours	22
Planned schedule	
Prerequisites	Charged particles interactions with matter
Description	Generalities on gaseous detectors. Ionization and transport phenomena in gases. Amplification in gases. Gaseous detectors: ionization chambers, proportional counters, MultiWire Proportional Chambers, Drift chambers, TPC, Geiger counters, streamer tubes, Resistive Plate Counters. Calorimetry. Electromagnetic and hadronic calorimeters. Calorimeter calibration and monitoring. Cherenkov detectors: DISC, RICH, DIRC. Transition radiation detectors. Micropattern detectors, dual readout calorimeters.

Module 2	Photodetection
Lecturer	Elisabetta Bissaldi (Politecnico di Bari)
Planned hours	16
Planned schedule	1 lecture per week two hours each
Prerequisites	Experimental particle physics background
Description	This course aims to provide the student with advanced knowledge of radiation measurements and detection techniques, from classic scintillation detectors to Silicon Photomultiplier devices. It requires an elementary background in radiation measurements, radiation matter interactions and basic electronics. The program includes Photon-matter interactions; Organic and Inorganic scintillators; Optical coupling; Solid-state photodetectors; SiPM technologies, properties and Applications.Part of the course will be devoted to laboratory sessions.

Module 3	Trigger and DAQ for Particle Physics
Lecturer	Massimo Della Pietra (Univ. Federico II NAPOLI)
Planned hours	10
Planned schedule	
Prerequisites	Experimental particle physics background
Description	Introduction to trigger and data acquisition system for experimental physics. Basic elements and definitions: trigger latency and trigger rate. Connection between trigger e data acquisition: dead time and busy status. Multilevel trigger systems, trigger for High Energy Physics at colliders. Integration of Trigger - DAQ and related systems Event building, Run Control, Online data quality. Description of most relevant trigger system for collider HEP: the trigger system of the LHC experiments. Trigger systems for fixed target experiments and for test-beam setup. Triggerless DAQ systems for particle and astroparticle physics. The impact of the trigger system efficiency on a physical measurement.

II. Signals Formation and Treatment in Particle Detectors

Module 1	Signals Formation
Lecturer	Marcello Abbrescia (uniba)
Planned hours	10
Planned schedule	5 lectures of 2 hours each
Prerequisites	Basic notions of electromagnetism and of particle detector physics
Description	- Electrostatics-Principles-Reciprocity-Induced currents-Induced voltages-Ramo-Shockley theorem-Mean value theorem- Capacitance matrix-Equivalent circuits; - Signals in: -Ionization chambers-Liquid argon calorimeters-Diamond detectors-Silicon detectors-GEMs (Gas Electron Multiplier) -Micromegas (Micromesh gas detector) -APDs (Avalanche Photo Diodes)-LGADs (Low Gain Avalanche Diodes)- SiPMs(Silicon Photo Multipliers) -Strip detectors-Pixel detectors- Wire Chambers -Liquid Argon TPCs.

Module 2	Shielding & Grounding
Lecturer	Alberto Aloisio (unina)
Planned hours	10
Planned schedule	5 lectures of 2 hours each (Calendar: March 4, 7, 8, 11 and 14)
Prerequisites	
Description	Shielding and grounding systems in the readout of sensors and detectors - Notes on the noise of active and passive components - Use of the analog simulator for the analysis of some case studies: noise of some basic configurations of operational amplifiers, effect of the detector capacitance on the noise

III. Multi-Messenger and Particle Astrophysics of Compact Objects

Module 1	Compact Objects
Lecturer	Francesco De Paolis (Università del Salento)
Planned hours	6
Planned schedule	
Prerequisites	Basic Astrophysics
Description	• Last stages of stellar evolution and formation of the compact objects • Phenomenological properties of neutron stars and pulsars Selected recent topics on the physics of the compact objects
Recommended texts	• Slides of the lecturer and texts suggested during the lectures
Assessment methods	Short essay on one of the topics developed during the lectures

Module 2	Neutrino Oscillations
Lecturer	Daniele Montanino (Università del Salento)
Planned hours	6-8
Planned schedule	
Prerequisites	Particle physics
Description	• Introduction to the neutrino masses, mixing and oscillations in vacuum and matter • Phenomenology of neutrino oscillations from terrestrial experiments and astrophysical sources, in particular solar neutrinos
Recommended texts	• Giunti, Kim, “Fundamentals of neutrino Physics and Astrophysics” (Oxford University Press, 2007) • Slides of the lecturer
Assessment methods	Short essay on one of the topics developed during the lectures or written test

Module 3	Supernova Neutrinos
Lecturer	Alessandro Mirizzi (Università di Bari)
Planned hours	6
Planned schedule	
Prerequisites	Particle physics
Description	• Supernova (SN) explosion mechanism • SN 1987A neutrino observation • Future SN neutrino observations • Neutrino oscillations in dense SN medium
Recommended texts	• G. Raffelt, "Stars as Laboratories for Fundamental Physics" (University of Chicago Press, 1996) • Slides of the lectures
Assessment methods	Short essay on one of the topics developed during the lectures

Module 4	Gravitation, Relativity and Black Holes
Lecturer	Mariafelicia De Laurentis (Università di Napoli)
Planned hours	6-8
Planned schedule	
Prerequisites	analytical mechanics, general relativity
Description	Rotating black holes: Kerr Spacetime and its global properties. Kerr black hole in Boyer-Lindquist coordinates. Zero-mass limit. Kerr-Schild form of the Kerr solution. Ergosphere and Horizon (Infinite redshift surface, Surface gravity, Surface geometry of horizon and ergo surface) Particle and Light Motion in Equatorial Plane. Matter accretion and black hole parameters change. Evolution in the black hole parameter space. Geodesics in Kerr Spacetime: General Case. Light Propagation. Black hole shadow. Generic properties of the rotating black hole shadows (Asymmetry, Flattening etc..). Image of Black Holes with the Event Horizon Telescope.
Recommended texts	Slides of the lectures
Assessment methods	Short essay on one of the topics developed during the lectures or written test

Module 5	Physics and Evolution of Supermassive Black Holes
Lecturer	Demetra De Cicco & Maurizio Paolillo (Università di Napoli)
Planned hours	6-8
Planned schedule	
Prerequisites	Basic classical physics and gravitation. Useful but not required: Module "Gravitation, Relativity and Black Holes", Introductory astrophysics, Physics of Galaxies
Description	The Discovery of Active Galactic Nuclei; Taxonomy of AGNs; clues to the interpretation: variability, luminosity and efficiency; steps toward unification: Eddington luminosity, Eddington mass and accretion rate; accretion efficiency. The Unified Model; AGN physical scales; broadband emission in AGNs; accretion disk spectrum; X-ray corona and other components. Observational evidence of the Unified Model: Quasar host galaxies; dynamical and reverberation mapping mass measurements; evidence of hidden BLR in Sy2; relativistic distortion in Fe lines; the Milky Way nuclear BH. AGN evolution from multi-wavelength studies of AGN populations optical, X-ray and infrared; luminosity function and number counts; AGN activity and number density evolution; resolving the Cosmic X-ray Background; Soltan argument: how to derive the current Black Hole mass density of the Universe; The link between Supermassive Black Holes and galaxy evolution; Evidences of AGN feedback in galaxies.
Recommended texts	Lecture slides; "Exploring the X-ray Universe", Seward & Charles,2010)
Assessment methods	Short essay on one of the topics developed during the lectures

Module 6	Gravitational waves and Gamma-Ray Bursts
Lecturer	Tristano Di Girolamo (Università di Napoli)
Planned hours	6-8
Planned schedule	
Prerequisites	Basic astrophysics and particle physics
Description	Generation of Gravitational Waves (GWs). Binary Black Holes (BBHs) as sources of GWs. Detection of GWs. Observations of GWs from BBHs. Gamma Ray Bursts (GRBs): observations and theoretical models. GRB progenitors. Black holes as central engines and final products of GRBs.
Recommended texts	Shapiro & Teukolsky, "Black Holes, White Dwarfs and Neutron Stars"
Assessment methods	Short essay on one of the topics developed during the lectures

IV. Fundamental Interactions: QCD, SM and BSM

Module 1	Perturbative QCD
Lecturer	Francesco Tramontano (NAPOLI)
Planned hours	12
Planned schedule	2 lectures per week two hours each
Prerequisites	Particle physics background
Description	The lectures introduce to some basic aspects and concepts of perturbative QCD: running coupling and asymptotic freedom, the parton model, infrared divergences and the factorization theorem, parton densities and parton evolution, colour coherence. Applications to e+e-annihilation, deep inelastic lepton-nucleon scattering and hadron-hadron collisions are discussed.

Module 2	Teoria di Regge
Lecturer	Giovanni Chirilli (Regensburg) ref. Claudio Corianò
Planned hours	10
Planned schedule	
Prerequisites	Particle physics background
Description	Regge Theory; High parton density; small x evolution equations and Wilson lines formalism; Background field method; High-energy Operator Product Expansion; High-energy factorization for scattering amplitudes;

Module 3	Weak decays and effective Hamiltonians in the Standard Model and beyond
Lecturer	Fulvia De Fazio (BARI)
Planned hours	16
Planned schedule	
Prerequisites	Particle physics background
Description	I describe in detail the effective Hamiltonians for weak decays of mesons constructed using the operator product expansion and the renormalization group methods. Applications to rare decays in the Standard Model and beyond will be considered.

Module 4	Higgs Boson Discovery and Measurements at LHC
Lecturer	Elvira Rossi(NAPOLI)
Planned hours	12-16
Planned schedule	May – July or September - December
Prerequisites	Particle physics background
Description	The course introduces the phenomenology of the recently discovered Higgs boson at LHC. An introduction to the LHC experiments and physics of the Higgs boson in the Standard Model (Higgs boson production and decay modes) will be given. The Knowledge Discovery in Database (KDD) approach in Particle Physics will be applied. KDD refers to the overall process of discovering useful knowledge from data and of the nontrivial extraction of implicit, previously unknown and potentially useful information from data. This method, largely used in Data Science, gives the basis of extracting useful information from large datasets and using it to make predictions or better decision-making. Moreover, the students will acquire the necessary background to learn about the main experimental methods used in the Higgs boson hunting as: statistical approach to search and discover a new particle; setting upper limits; how to measure the main properties of a new particle (mass, signal strength, spin-parity, couplings,...): classical approaches and most up-to-date Machine Learning techniques.

Module 5	Beyond Standard Model Searches at LHC
Lecturer	Francesco Cirotto (Napoli)
Planned hours	12-16
Planned schedule	May – July or September - December
Prerequisites	Particle physics background
Description	Although Higgs discovery at the LHC completed the Standard Models puzzle, there are still many open questions. The LHC Beyond Standard Mode (BSM) Physics programme covers a wide range of theoretical models: Supersymmetry, Dark Matter and others. The course offers an introduction to the BSM phenomenology at the LHC, with an overview on most recent results. There are several approaches to these searches, based on the complexity of the theoretical model under investigation and the energy available at colliders. The course offers to students an overview on typical analysis strategies developed in these searches with the presentation of model dependent and independent results. Moreover, the most recent approaches with Machine Learning will be discussed, showing its application in several cases, from background estimation to signal region definition. Hands-on sessions provided can lead students to a deeper comprehension of these searches.

V. Artificial Intelligence and Machine learning

Module 1	Data Modelling
Lecturer	Nicola Amoroso (UniBA)
Planned hours	10
Planned schedule	
Prerequisites	
Description	Introduction: graph theory. Different graph models. Nodal and edge characterization. Local and global properties. Community detection. Learning: Basic definitions, bias, variance and cross-validation. Supervised Models. Deep Learning. Unsupervised models: Clustering.

Module 2	Machine Learning: Basis and Applications
Lecturer	Giorgio De Nunzio & Giuseppe Palma
Planned hours	10
Planned schedule	
Prerequisites	
Description	ML taxonomy: supervised, reinforcement, unsupervised; Regression: linear regression, GLM. Classification: scores (confusion matrix and related measures; ROC curve; calibration; cross entropy, Brier score), class imbalance. Bias-Variance tradeoff: underfitting, overfitting. Perceptrons and Shallow Feed-Forward Neural Networks. Applications of regression and classification: case studies in Physics and Medicine with synthetic and public access data (python).

Module 3	Artificial Intelligence for Social Good
Lecturer	Loredana Bellantuono (UniBA)
Planned hours	16
Planned schedule	8 Class lectures during Spring
Prerequisites	
Description	Artificial Intelligence for Social Good (AI4SG) is a new research field, that tackles important social, environmental, and public health challenges by using methods of complex system analysis, such as network models and machine learning. Using a top-down approach, AI4SG aims at delivering positive social impact in accordance with the priorities outlined in the United Nations' 17 Sustainable Development Goals (SDGs). The course has an application-oriented approach and is organized in tutorials focused on the analysis of relevant case studies related to the achievement of SDGs. **Programme:** • Artificial Intelligence for Social Good (AI4SG): why and how. A primer on the main approaches to AI4SDG. The Python toolbox for big data analysis and visualization. • Complex systems and network science. Structure and properties of network graphs representing complex systems. • Case study 1 – Towards a more equitable education system (SDGs 4, 10). A complex network model to measure structural inequalities and territorial bias in the access to quality education. • Case study 2 – Social psychiatry (SDG 3). Investigating the impact of societal and environmental factors on the incidence of psychiatric disorders. • Machine Learning: predicting continuous variables with regression analysis. • Case study 3 – AI for the most vulnerable: interplay between hunger and climate change (SDGs 1, 2, 3, 13). Predicting food insecurity across sub-Saharan Africa with multivariate regression on data concerning prices, assets, and climate. • Natural Language Processing: preprocessing of text data, topic detection and sentiment analysis. • Case study 4 – The language of sustainability on social media (all SDGs). Topic modelling and sentiment analysis to unveil information from sustainability speech on Twitter. **Recommended texts:** Sebastian Raschka, Vahid Mirjalili, "Python Machine Learning" – Packt Publishing Ltd (2017). Dmitry Zinoviev, "Complex Network Analysis in Python" – The Pragmatic Programmers, LLC (2018). **Recommended texts:** Seminar on a selected topic or presentation of a project concerning Artificial Intelligence for Social Good (AI4SG).

VI. Quantum Information and Quantum Technologies

Module 1	Physical Coherence and Correlation Functions
Lecturer	Saverio Pascazio (UniBA) (NOT DELIVERED in 2023)
Planned hours	16
Planned schedule	Eight two-hour lectures
Prerequisites	Background in quantum theory, technologies and applications
Description	Optical Fluctuations and Coherence. Classical and Quantum theory. The Radiation field. Experimental milestones. Measuring correlation functions. Equilibrium equal-time (spatial) correlation functions Equilibrium equal-position (temporal) correlation functions. Beyond equilibrium. Phase transitions and correlation functions.

Module 2	Introduction to Quantum Computation
Lecturer	Luigi Martina (UniSalento)
Planned hours	16
Planned schedule	Eight two-hour lectures
Prerequisites	Quantum Mechanics and Statistical Mechanics
Description	Since at least a couple of decades, the Physics of Information and Computation has been a recognized as an autonomous discipline. In fact, the latter fields should be linked to the study of the underlying physical processes, namely of the quantum mechanical universe. But the intrinsic probabilistic character of the quantum measurements and the non-commutative algebra of the observables induce important modifications in the central results of classical information theory, including: quantum parallelism, compression of quantum information, bounds on classical information encoded in quantum systems, bounds on quantum information sent over a noisy quantum channel, efficient quantum algorithms and quantum complexity. The course will touch the above topics.

Module 3	Quantum imaging
Lecturer	Milena D'Angelo (UniBA) Cosmo Lupo (PoliBa)
Planned hours	16
Planned schedule	Eight two-hour lectures
Prerequisites	Background in quantum theory and optics. Attendance of either one of the two above modules is suggested.
Description	From classical to quantum imaging. Klyshko advanced wave model. Ghost imaging and diffraction, from first protocols to recent advances (differential GI, computational GI, compressive GI,..). Single-pixel imaging. Super-resolution: NOON states, and Quantum Fisher information. Sub-shot-noise imaging. Imaging by undetected photons. Imaging through turbulence and scattering media, and imaging around corners. Correlation plenoptic imaging: from principles to applications.

VII. Experimental High-Energy Astroparticle Physics

Module 1	Experimental Techniques in Astroparticle Physics
Lecturer	Giovanni Marsella (Palermo)
Planned hours	16
Planned schedule	
Prerequisites	Basic particle physics, astrophysics and detectors
Description	Description of the principal experimental techniques in Astroparticle Physics Contents: • Introduction to Cosmic Ray (CR) sources • Primary CRs, acceleration mechanism, propagation • Secondary CRs, atmospheric showers • Detection techniques in Space, Extensive Air Shower arrays and underground detectors • Presentation of the principal experiments and recent results
Recommended texts	
Assessment methods	

Module 2	HE and VHE Observations from Extragalatics Sources
Lecturer	Lorenzo Perrone et al. (Lecce)
Planned hours	5-10
Planned schedule	
Prerequisites	Basic particle physics, astrophysics and detectors
Description	The lectures intend to cover the description of the detection techniques of ultra-high energy cosmic rays (Pierre Auger Observatory, Telescope Array) and the current status of the art (result and perspectives) in the field.
Recommended texts	Review papers and journal papers.
Assessment methods	Lessons, final report, hands-on session

Module 3	HE Transients and the Multimessenger Context
Lecturer	Elisabetta Bissaldi (Politecnico di Bari)
Planned hours	16
Planned schedule	
Prerequisites	Basic astrophysics, Detectors
Description	- Transient phenomena in the gamma-ray sky: Gamma-Ray Bursts (GRBs), Soft Gamma Repeaters, Terrestrial Gamma-Ray Flashes; Solar Flares. Temporal and spectral characteristics; - Multi-frequency and Multi-messenger studies; LIGO/Virgo gravitational wave (GW) events and follow-up observations; The case of GRB 170817A / GW 170817; IceCube neutrino events and follow-up observations; The case of TXS 0506+056; Other recent discoveries in the field.
Recommended texts	1. Longair - “High-energy astrophysics” 2. De Angelis & Pimenta - “Introduction to Particle and Astroparticle Physics” 3. Recent Publications
Assessment methods	Lessons, final report

Module 4	Experimental Techniques in Space Science
Lecturer	Beatrice Panico (Unina)
Planned hours	10
Planned schedule	
Prerequisites	Basic of cosmic ray physics, Detectors
Description	The course will present the experimental techniques applied in the observation of cosmic rays from space. An overview on the next generation of space-based instrument for cosmic rays measurements will be provided. The course is designed for students performing doctoral studies in experimental astroparticle physics. Summary: 1) Open scenarios on the basic physical processes involving low energy cosmic rays, coming from astrophysical accelerators in high-density regions and from Dark Matter. 2) Methods and observing techniques to study cosmic rays from space 3) Current research in multimessenger astroparticle physics and in Space Wheather. 4) UHECRs from space 5) Extracting a spectral energy distribution from data provided by different experiment During the course some practical experiences with students are foreseen: from data handling to software design and development, statistical analysis. In specific cases students are allowed and invited to investigate in-depth topics and to discuss during lectures.
Recommended texts	To be defined
Assessment methods	Students will be evaluated based on a final short seminar on an article or a modern research topic selected according to their interest.

Module 5	**Dark Matter in cosmology and astrophysics**
Lecturer	Fabio Iocco (Unina)
Planned hours	14 in 7 lectures
Planned schedule	
Prerequisites	Basic of particle and particle physics
Description	1-2) Evidence of a non-electromagnetically interacting compomenet in astrophysical systems. (*Dark *matter in the CMB, Galaxy clusters, local disk galaxies). 3) Properties of the non EM-interacting component (Dark matter, DM) from other astrophysical probes (Lyman-alpha forest, etc.) 4) Candidates of Dark Matter: non-exotic forms of matter and the search for it. 5) Candidates of Dark Matter: beyond the standard model of particle physics. 6) Search for specific candidates: the WIMP. Direct and indirect searches. 7) Alternatives to DM, the problems of LCDM paradigm.
Recommended texts	to be defined
Assessment methods	To be defined

Module 6	Astrophysics with ultra-high-energy neutrinos and Neutrino Telescopes
Lecturer	P. Migliozzi (INFN-Napoli)
Planned hour	8
Planned schedule	
Prerequisites	Basic astrophysics and particle physics
Description	Meson production, atmospheric neutrinos, the discovery of high-energy neutrinos, Sources of astrophysical neutrinos, Cosmic neutrino flux estimates, Neutrino detection principle and event topologies, The need for km3 neutrino telescopes, Water and ice properties, Operating neutrino telescopes, Results from neutrino telescopes
Recommended texts	M. Spurio, “Particle and Astrophysics” T. Stanev, “High-Energy Cosmic Rays”
Assessment methods	Short essay on one of the topics developed during the lectures

VIII. Statistical Physics for Complex Systems

Module 1	Active Matter and Complex Fluids
Lecturer	Giuseppe Gonnella (UniBA) – Antonio Lamura (CNR-Bari)
Planned hours	16
Planned schedule	Eight two-hour lectures
Prerequisites	Background in classical physics and statistical mechanics
Goal	The purpose of these lectures is to give an introductory overview to recent research developments in the field of applications of statistical and theoretical physics to complex fluids, soft matter and biological systems.
Description	Statistical physics and biological systems. Active matter: basic particle and continuous models. The phase diagram of passive and active colloids. Topological transitions. Complex fluids: theoretical modeling. Polymers: static and dynamical properties in dilute conditions. Ternary mixtures with surfactant: self-aggregation, active and double emulsions. Basic rheological behavior of complex fluids. The yielding transition. Simulations methods in soft and active matter. Molecular dynamics, Multi-Particle Collison Methods, Lattice Boltzmann Methods.

Module 3	Stochastic Processes and Analysis of Correlations
Lecturer	Eugenio Lippiello (University of Campania "Luigi Vanvitelli")
Planned hours	16
Planned schedule	Eight two-hour lectures
Prerequisites	Background in classical statistical mechanics.
Goal	The purpose of these lectures is to give a simple mathematical introduction to the description of stochastic processes with innovative applications in the field of epidemiology and earthquake data time- series analysis.
Description	Markov processes. Master and Fokker Plank equations. Stochastic energetics. Branching processes. Watson-Galton model. Application to genetics. Epidemic models. Applications to epidemiology and earthquake occurrence. Analysis of correlations in stochastic signals. Detrended Fluctuation Analysis. Power spectrum of a signal.

IX. Biophysics for Health and Environment

Module 1	Biophysical mechanisms and therapeutic implications of human exposure to ionising radiation
Lecturer	Lorenzo Manti (Università Federico II Napoli)
Planned hours	20
Planned schedule	10 lectures of 2 hours each
Prerequisites	Fundamentals of radiation-matter interaction
Description	The aim of the course is to provide an overview of the unique biological action exerted by ionizing radiation (IR). The ensuing effects at cellular and tissue level are governed by the spatio-temporal mode with which energy deposition occurs at the nanometer level (i.e., at the scale of the DNA) and are influenced by a cascade of complex biomolecular responses. The course will therefore illustrate the main biophysical principles on which modern radiotherapy (RT) relies. New approaches will be also discussed such as the use of accelerated particle beams (hadrontherapy) and the exploitation of nuclear fusion reactions where physics can give an essential contribution to IR-based cancer therapy

Module 2	Biophotonics for clinics and environment
Lecturer	Maria Lepore (Università della Campania «Luigi Vanvitelli») - Ines Delfino (Università della Tuscia)
Planned hours	16
Planned schedule	
Prerequisites	Basic concepts of optical techniques
Description	The course will deal with the application of optical techniques to the development of new diagnostic strategies and environment monitoring tools. Vibrational and fluorescence spectroscopies will be used for investigating biofluids, human tissues, radioesposed cells and enzymes in order to monitor biological processes and to develop sensor devices.

X. Nuclear Theory and Fundamental Interactions

Module 1	Chiral Effective Field Theory in Nuclear and Particle Physics
Lecturer	Luca Girlanda (Università del Salento)
Planned hours	10-12
Planned schedule	2 hours/week
Prerequisites	Quantum Field Theory
Description	The lectures will cover aspects of non-perturbative QCD, with special reference to the approximate chiral symmetry and its realizations. After a brief recollection of the old current algebra techniques and soft pion theorems, the modern approach based on effective Lagrangians will be discussed. The foundation and scope of Chiral perturbation theory will be presented in the meson sector and extended to include a single baryon. Finally, the complications pertaining to the few-nucleon sector will be addressed in the context of Weinberg proposal to explain the hierarchy of nuclear interactions. The importance of a robust quantification of the nuclear uncertainty, based on the convergence pattern of chiral expansions, for the research in fundamental interactions will be emphasized.

Module 2	Theory of Nuclear Forces and Nuclear Matter
Lecturer	Luigi Coraggio (UniCampania)
Planned hours	16
Planned schedule	
Prerequisites	
Description	The goal of this course is to introduce PhD students to our present knowledge of the theory of nuclear forces and, as its application, of infinite nuclear matter. First, the basic phenomenological features of the nuclear potential are presented, and their connection to the main aspects of strong force. Then, we start to follow the path that from the Yukawa potential, through models based on the meson theory, historically leads to the present approach to the derivation of two- and three-body nuclear forces which are rooted in the QCD by way of the effective field theory. Last section is devoted to study the nuclear environment that is considered the best testing ground for models of nuclear forces, that is the infinite nuclear matter. To this end, basic knowledge of the derivation of the equation of state of nuclear matter in terms of the Brueckner theory will be provided to the students. This topic may be of interest also for those scholars that are interested in astrophysical systems such as the neutron stars, whose structure may be described in terms of the equation of state infinite nuclear matter.