SPACE Area Courses (AA 2022-2023)

- **Introduction to General Relativity (PILLAR)**
  Lecturer: Prof. Capozziello
  Email: salvatore.capozziello@unina.it
  Period: November-December | Hours: 24
  Teaching mode: in presence
  The course intends to provide an introduction to General Relativity for which knowledge of the basic principles of Special Relativity, Electromagnetism and Classical Mechanics is required. It is aimed at graduates in engineering, physics and mathematics.

- **Introduction to Cosmology (PILLAR)**
  Lecturer: Dr. Benetti and Dr. D’Agostino
  Email: micol.benetti@unina.it, rocco.dagostino@unina.it
  Period: November-December | Hours: 24
  Teaching mode: in presence
  The course addresses the theoretical foundations of modern cosmology, and the observational basis of the standard cosmological model. The main physical concepts and fundamental events in the cosmic history are introduced, including the theory of inflation, the generation of cosmic microwave background anisotropies from primordial inhomogeneities, and the process of structure formation.

- **Statistical Mechanics: from basic concepts to applications in Complex Systems, Astrophysics and beyond (PILLAR)**
  Lecturer: Prof. Nicodemi
  Email: nicodem@na.infn.it
  Period: January - February | Hours: 24
  Teaching mode: online
  The course introduces the theory of Statistical Mechanics, from its fundamental concepts to more advanced applications in Complex Systems, Astrophysics and beyond.

- **Introduction to Astrophysics (PILLAR)**
  Lecturer: Prof. Risaliti
  Email: guido.risaliti@unifi.it
  Period: January - February | Hours: 24
  Teaching mode: in presence
  The curse describes the physical processes determining the inner structure of stars, including hydrostatic equilibrium, the equation of state of stellar matter, nuclear fusion, radiative and convective transport, the main mechanisms of interaction between radiation and matter. We will then discuss the main aspects of stellar evolution with a final brief treatment of the main properties of white dwarfs and neutron stars. Also, we will describe the most common techniques for measuring cosmic distances.

- **Introduction to Quantum Mechanics (PILLAR)**
  Lecturer: Prof. Miele
  Email: gannaro.miele@unina.it
  Period: March - April | Hours: 24
  Teaching mode: in presence
  The course aims to provide the main concepts of this very counterintuitive theory as well as the mathematical tools necessary to tackle quantitatively the subject. In particular the Schrödinger equation will be introduced a studied for some particular quantum systems. The axiomatic structure of QM will be outlined and discussed.

- **Introduction to Astroparticle Physics (PILLAR)**
  Lecturer: Prof. Vissani
  Email: francesco.vissani@lngs.infn.it
  Period: March - April | Hours: 24
  Teaching mode: in persence
  The course introduces the main aspects of astro-particle physics, treating the most relevant methods and results of particle physics. Astro-particle physics covers research in astrophysics that essentially involve the study of the smallest parts of matter, and, vice versa, particle investigations with an impact on our understanding of celestial objects and of the cosmos.

- **Introduction to Deep Learning (PILLAR)**
  Lecturer: Prof. Poggi and Dr. Gragnaniello
  Email: poggi@unina.it , diego.gragnaniello@unina.it
  Period: May - June | Hours: 24
  Teaching mode: Online
  Aim of this introductory course is to provide fundamental concepts and theoretical tools on machine learning, artificial neural networks, deep learning. In addition, coding sessions in Python and Keras will provide practical tools to implement and use popular deep learning models. Image processing problems will be used to demonstrate concepts and tools.

- **Black Hole Physics**
  Lecturer: Dr. De Falco
  Email: vittorio.defalco-ssm@unina.it
  Period: March - April | Hours: 12
  Teaching mode: in presence
  In this course, we aim at analysing the geometric features and structures of four classical black hole solutions in General Relativity (Schwarzschild, Kerr, Reissner–Nordström, and Kerr–Newman). Besides to focus on the mathematical aspects, we provide also the physical meaning and their applications in the current high-energy astrophysical panorama.

- **The Transient Universe: Cosmic Explosions**
  Lecturer: Prof. Massimo della Valle
  Email: massimo.dellavalle@inaf.it
  Period: May - June | Hours: 12
  Teaching mode: mixed
  We will deal with the study of the transient Universe. Particular emphasis will be given to the final stages of stellar evolution, such as: *Nova, Supernova, Gamma-ray Burst* and *Kilonova* events. We will briefly describe the mechanisms of energy production in these stellar explosions and the use of this class of astrophysical objects to measure cosmic distances.

- **Quantum Information, Complexity and Black Holes**
  Lecturer: Prof. Alioscia Hamma
  Email: alioscia.hamma@unina.it
  Period: May-June | Hours: 12
  Teaching mode: in presence
  This course is aimed at providing advanced tools from Quantum Information theory for the description of complex quantum phenomena and information scrambling in local quantum systems, with an emphasis on black holes. We will give a mathematical description of the spreading of information and how causality emerges in local quantum systems. The interplay between entanglement, complexity and information paradox in black holes will be discussed together with a survey of open research problems.

- **Standard Model of Fundamental Interactions**
  Lecturer: Prof. Sannino
  Email: sannino@cp3.sdu.dk
  Period: May-June | Hours: 12
  Teaching mode: online
  The course introduces the student to the fascinating world of fundamental interactions. The students will learn how to fuse quantum field theory, group theory and other deep mathematical tools to bridge the gap between theory and experiments in particle physics. We will arrive at the frontier of our understanding of the ultimate laws of nature

- **Classical and Quantum Modifications to General Relativity**
  Lecturer: Dr. Francesco Bajardi
  Email: f.bajardi@ssmeridionale.it
  Period: Apr-May | Hours: 12
  Teaching mode: in presence
  The course introduces the basic foundations of General Relativity and the shortcomings exhibited by the latter on different energy scales. Then, different modified gravity models, aiming to address part of these issues, are presented. The end of the course is devoted to the study of the ADM formalism and the quantum cosmological framework applied to General Relativity modifications.

- **Inflation in the Early Universe: theoretical developments and observational predictions**
  Lecturer: Prof. Matarrese
  Email: sabino.matarrese@pd.infn.it
  Period: May-June | Hours: 12
  Teaching mode: online
  In this course we analyse kinematics and dynamics of inflation, the generation of scalar and tensor perturbations during inflation as well as the evolution of perturbations and the gauge issue. We also treat the observational predictions of inflation as the CMB anisotropies and polarization and Large-Scale cosmic structures. Primordial gravitational waves and prospects for their future detection are also addressed.