SPACE Area Courses (AA 2024-2025)

- **Introduction to General Relativity**
  Period: November-December | Hours: 24
  Teaching mode: in presence
  Lecturer: Prof. Capozziello
  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**
  Period: December - January | Hours: 24
  Teaching mode: in presence
  Lecturer: Prof. Benetti
  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 cosmic history are introduced, including the theory of inflation, the generation of cosmic microwave background anisotropies from primordial inhomogeneities, and the structure formation process.

- **Classical and quantum alternatives to general relativity**
  Period: January | Hours: 12
  Teaching mode: in presence
  Lecturer: Dr. Bajardi
  In this course, alternatives and extensions to general relativity are examined to address its limitations at different energy scales. Particular focus is given to renormalizability and the cosmological constant problem. To modify general relativity, the Noether symmetry approach is introduced, along with its application to quantum cosmology. Finally, as a step toward a quantum framework for gravity, gauge theories and field theories in curved spacetime are explored.

- **Introduction to Astrophysics**
  Period: January - February | Hours: 24
  Lecturer: Prof. Risaliti and Napolitano
  Teaching mode: in presence
  The course covers the physical processes governing stars, including hydrostatic equilibrium, nuclear fusion, and radiation-matter interactions, followed by stellar evolution and the properties of white dwarfs and neutron stars. It also explores galaxy physics, focusing on classification, photometry, kinematics, and dynamics. Students will gain both observational and theoretical knowledge, providing a strong foundation for studying stellar and galactic evolution in astrophysics and cosmology

- **Introduction to Astroparticle Physics**
  Period: February - March | Hours: 24
  Teaching mode: in presence
  Lecturer: Dr. Saviano and Dr. Chianese
  The course will address challenges in understanding the early and recent Universe, focusing on the connections between astrophysics and particle physics. It will review multi-messenger astrophysics, covering neutrinos, cosmic rays, and gamma rays, and present current knowledge of dark matter, including possible candidates like primordial black holes. Observational and experimental techniques will also be briefly explored.

- **Introduction to Aerospace**
  Period: March- April | Hours: 24
  Teaching mode: in presence
  Lecturer: Dr. Mungiguerra and Dr. Renga
  The course covers engineering challenges in space mission design and operations, focusing on the mission life-cycle and elements. It addresses three areas: GNSS, space research, and satellite reentry. GNSS principles, error sources, and advanced concepts are discussed. The course also highlights the role of microgravity in research and applications, and introduces hypersonic aerothermodynamics and spacecraft thermal protection during reentry.

- **Quantum Information**
  Period: March -April | Hours: 24
  Teaching mode: in presence
  Lecturer: Prof. Marmo and Prof. Hamma
  The course provides a modern formulation of quantum mechanics based on geometric and tomographic descriptions, aligning with current research. Also, we will explore advanced topics in quantum information theory, including the geometric description of quantum mechanics and statistical properties in Hilbert space, with a focus on typicality and equilibration.

- **Scientific Writing**
  Period: March - May | Hours: 24
  Teaching mode: in presence
  Lecturer: Prof. Russo
  The course offers an introduction to scientific publication in international journals, covering reasons for publishing, journal selection, writing style, ethics, editing, revisions, proofreading, and manuscript correspondence. It also includes the editorial structure of journals (Editor, associates, board members, publisher), the review process, review methods, and understanding bibliometric indices. Evaluation is based on exercises related to the course material.

  Introduction to Quantum Field Theory in flat and curved space
  Period: May | Hours: 24
  Teaching mode: in presence
  Lecturer: Prof. Sannino and Prof. Taronna
  In this course we will introduce the basic tools to understand Quantum Fields on flat and curved backgrounds, from canonical quantization and path integral to Black Holes and Inflation, arriving at the most modern developments which are centered around the “Holographic Principle”.

- **Observational Cosmology**
  Period: April- May | Hours: 12
  Teaching mode: in presence
  Lecturer: Prof. Benetti
  This course builds on *Introduction to Cosmology* by calculating observational predictions to compare with data. It focuses on the CosmoMC program, a Fortran Markov-Chain Monte-Carlo (MCMC) engine for exploring cosmological parameters. Using CAMB to solve Einstein-Boltzmann equations, I will explain its functionalities and guide classroom exercises to modify the code for alternative cosmological models. The course also covers CosmoMC installation, parameter modification, and result analysis for accurate theoretical model evaluation.

- **Experimental methods in Astroparticle Physics**
  Period: May | Hours: 12
  Teaching mode: in presence
  Lecturer: Prof. Guarino
  This course covers modern experimental methods in astroparticle physics. It begins with particle detectors, then explores their integration into complex instruments. Techniques for cosmic ray physics, X-ray and gamma-ray astronomy, neutrino astronomy, dark matter searches, and gravitational wave detection are discussed. Numerous examples from astroparticle physics experiments illustrate these methods and their specific applications.