Course title:

Introduction to astro-particle and particle physics

Duration [number of hours]**: 24**

PhD Program [MERC/MPS/SPACE]**: SPACE**

Name and Contact details of unit organiser(s):

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Course Description:

Astro-particle physics was born ~30 year ago from branches of particle physics which extended to areas traditionally belonging to astrophysics and encompassing considerations of cosmology, nuclear physics, etc. Even if the boundaries of such a young discipline are not rigidly marked, a rough definition can be ventured: it covers researches 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. In this way the links with oldest scientific investigations are evident; however, it is also clear - in view of the recent advances - that this discipline touches many lively research topics. The main aspects of astro-particle physics will be presented, while providing an introduction to the most relevant methods and results of particle physics.
[Main synergies are with the courses by Capozziello, Della Valle, Miele and Sannino]

Syllabus:

1. **Introduction:** a) Fundamental constants and important quantities. Estimates and mnemonic tricks. b) Recalls of thermodynamics and statistical mechanics. Recalls of electromagnetism. c) Quantum mechanics. Photons. Dirac equation and antimatter. d) Elements of nuclear physics. Radioactivity and isotopes. Protons and neutrons. Beta stability and semi-empirical mass formula.
2. **Astronomical and astrophysical topics:** a) Distances and masses in astronomy. Methods of investigation / multiple messengers. Dark matter in astronomy. b) The sun and some special observation methods. Basics of stellar evolution. Neutron stars, black holes and their formation. c) Galaxies and their characteristics. AGN. The cosmos and the early universe. d) Cosmic rays and high energy radiation.
3. **Particles physics:** a) The world of particle physics & and general aspects of quantised field theory. b) Electroweak theory. Standard model of elementary interactions. c) Neutrino physics. Masses and oscillations.
4. **Specific topics highlighted:** a) Origin of elements. Baryonic matter in the universe Baryonic and leptonic number. Majorana mass. b) Phenomenology and astrophysics of neutrinos: Solar neutrinos. Supernova neutrinos. Atmospheric neutrinos. Very high energy neutrinos and why they are of interest. c) Limits of the standard model. Evidence and clues for the existence of new physics. Extensions of the standard model, possible verifications. b) Hints and particle physics candidates for dark matter.

Assessment

Typical manner to conclude the course is a written project to be agreed together, based on the PhD student's proposals. Then, final discussion, in person or by email, skype, etc. During the course, exercises are assigned to ensure sufficient mastery of the subject, which students are strongly encouraged to carry out and discuss, among themselves and with the lecturer.

Suggested reading and online resources:

Several reading proposals will be shared electronically. More proposals from participants are very strongly encouraged, also with a view to enriching or developing part of the thesis project.