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Nuclear challenges for nucleosynthesis studies

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One of the major issues in modern astrophysics concerns the analysis and understanding of the present composition of the Universe and its various constituting objects. Nucleosynthesis models aim to explain the origin of the
different nuclei observed in nature by identifying the possible processes able to synthesize them. Though the origin of most of the nuclides lighter than iron through the various hydrostatic and explosive burning stages in stars is now quite well understood, the synthesis of the heavy elements (i.e. heavier than iron) remains obscure in many respects. The major mechanisms called for to explain the production of the heavy nuclei are i) the slow neutron-capture process (or s-process) occurring during specific hydrostatic stellar burning phases, ii) the rapid neutron-capture process (or r-process) believed to develop during the explosion
of a star as a type II supernova or during the merging of two compact objects, and iii) the photodisintegration process (or p-process) taking place in the high-temperature environment of type-Ia or type-II supernovae. The stellar nucleosynthesis requires a detailed knowledge not only of the astrophysical sites and physical conditions in which the processes take place, but also the nuclear structure and interaction properties for all the nuclei involved.

This seminar describes our present understanding of the stellar nucleosynthesis processes as well as the many experimental and theoretical efforts devoted to determine the related nuclear physics inputs of relevance. These include nuclear structure as well as decay and reaction properties of relevance in astrophysical environments. A special attention will be paid to the complex physics related to the r-process nucleosynthesis and the new developments in the light of the recent observation of the binary neutron star merger GW170817.

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