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Current quests in nucleosynthesis: present and future neutron induced reactions measurements

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The nucleosynthesis of the elements in the stars was well established in the Fifties in the works of B2FH and Cameron. However, astrophysical models cannot provide a complete description of the physical properties of the stellar sites as well as the solar abundances of the different elements. For instance, the main part of the elements with mass above iron can be ascribed to neutron captures and successive beta decays, either during the He burning in Red Giant stars s-process (neutron captures occur at slow rate that beta decay) or Supernovae r-process (rapid rate). On the other side, there are 32 proton-rich stable isotopes in the mass region 74<A<196 that cannot be formed in neutron capture scenarios. These isotopes are attributed to the p-process (photo-dissociation and proton capture) and their abundances are 10 to 100 times less than the neighboring s- and r-nuclei. The astrophysical site of p-process is still under discussion and the astrophysical models cannot explain the solar abundances in a single scenario. The current favored site is the explosive burning in type II Supernovae. Moreover, at temperatures around 3e9 degrees all nuclear processes occur in great profusion, including those involving heavier nuclei. The abundances of the elements in the iron peak could be synthesized under conditions of temperature and density such that statistical equilibrium (e-process) between nuclei and the free protons and neutrons was achieved. This equilibrium can be reached through the beta processes among the nuclei in a time-scale long enough.

One of the most important quantities for the astrophysical models are the cross-sections of the reactions involved in the different processes mentioned and in particular the Maxwellian-averaged cross sections (MACS). The MACS of the elements can be measured by the time-of-flight (TOF) or the activation techniques. Here we present an overview of recent measurements with impact in astrophysics in different facilities with different methods and techniques. We consider n_TOF at CERN as an example of large facility and the TOF technique. Moreover, we will try to motivate the research in new ideas and methods to provide new data in large and small facilities. According to this we discuss the measurements of the MACS of different elements at CNA (Seville, Spain) as example of a small facility, the activation technique and new method. Finally, and in deep relation with the previous, we show the very challenge measurements at Legnaro (Italy) that should be possible in the near future with a big impact in astrophysics.