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Underground Study of Big Bang Nucleosynthesis in the Precision Era of Cosmology

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Big Bang Nucleosynthesis (BBN) is the first probe of cosmology and particle physics. Assuming Standard model of cosmology and particle physics , light elements such as deuterium, helium and lithium were produced in the first minutes of cosmic time. The amount of each primordial nuclide depends on the expansion rate of the Universe and on the baryon density . The expansion rate is governed by the number of relativistic species (photons and three neutrino families in the standard model), while the baryon density has been recently inferred with high accuracy by the PLANCK collaboration, through the analysis of cosmic microwave background (CMB) data. Thus, BBN theory provides definite predictions for the abundances of primordial elements, as far as the knowledge of the relevant nuclear processes of the BBN chain is accurate. At BBN energies (Ecm between 30 and 300 MeV) the cross section of many BBN processes is very low because of the Coulomb repulsion between the interacting nuclei. For this reason it is convenient (if not mandatory) to perform the measurements deep underground. Presently the world's only facility operating underground is LUNA (Laboratory for Undergound Nuclear astrophysics) at LNGS (Laboratorio Nazionale del Gran Sasso, Italy). In this presentation the BBN measurement of LUNA are briefly reviewed and discussed. The ongoing study of the D(p,gamma)3He reaction at BBN energies will be discussed more in detail. It will be shown that a precise measurement of this process is of primary importance to: derive the baryon density of universe with accuracy comparable to the one obtained by Cosmic Microwave Background (CMB) experiments; constrain the existence of dark radiation, i.e. unknown relativistic species existing in the universe, in order to constrain; Compare the experimental data with nuclear ab initio calculations.

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