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Nuclear Astrophysics at LUNA: Status and Perspectives

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Except for primordial hydrogen, helium and few other light species, all chemical elements in the universe originate from nuclear reactions occurring in both quiescent and explosive stages of stellar evolution. Such reactions take place over a narrow energy region, typically well below the Coulomb barrier between the interacting nuclei [1]. As a result, their reaction cross sections are vanishingly small and difficult to measure at surface laboratories. In many cases, significant breakthroughs can be achieved underground, where the cosmic-ray induced background can be reduced by several orders of magnitude [2].

The Laboratory for Underground Nuclear Astrophysics (LUNA) of the INFN at Gran Sasso (Italy) has pioneered low-energy nuclear reaction studies for over 25 years now, allowing –often for the first time –the study of key reactions directly at the relevant astrophysical energies. In particular, experimental studies of hydrogen burning reactions in the pp-chain, the CNO cycles, and NeNa-MgAl cycles have led to major improvements in our understanding of nucleosynthesis processes in various environments, from the Big Bang, to our Sun, to Asymptotic Giant Branch stars and classical novae [3,4].

Here, I will review some of the most recent results and present future perspectives both at LUNA and elsewhere.

[1] C. Iliadis, Nuclear Physics of Stars, Wiley-VCH, 2nd Edition (2015)
[2] H. Costantini et al., Rep. Progr. Phys. 72 (2009) 086301
[3] C. Broggini et al., Ann. Rev. Nucl. and Part. Phys. 60 (2010) 53
[4] C. Broggini et al., Prog. Nucl. Part. Phys. 98 (2018) 55

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