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Exploring nuclear astrophysics with heavy-ion storage rings

Heavy-ion storage rings coupled to radioactive ion beam facilities offer unique capabilities for nuclear structure and astrophysics experiments. There are presently three operational facilities, namely the Experimental Storage Ring (ESR) at GSI in Darmstadt, the experimental Cooler-Storage Ring (CSRe) at IMP in Lanzhou, and the Rare-RI Ring (R3) Facility at RIKEN at which several research programs are being pursued.

Well-established are mass measurements of short-lived nuclei as well as decay studies of highly-charged radionuclides. These nuclear properties are the important input for the astrophysical nucleosynthesis calculations. While the former determine the pathways of various processes on the chart of nuclides, the latter affect the final elemental abundances.

In addition, storage rings are being considered for nuclear reaction studies. Compared to external target experiments, here a thin windowless internal gas target combined with high revolution frequencies of stored ions offer advantageous conditions for a range of experiments. For instance it has been shown that proton capture reactions can successfully be measured in the ESR [1]. The goal is to conduct proton and alpha-capture reactions directly in the Gamow window of the astrophysical p-process.

Research programs at storage rings have proven their high discovery potential, which is clearly indicated by a number of new storage ring projects started around the world. In the last years it became evident that stored beams at low energies offer huge scientific potential. The TSR@HIE-ISOLDE project compiled physics cases in nuclear structure, astrophysics, atomic- and neutrino physics as well as for the tests of fundamental symmetries. Although, the project could not be realized at ISOLDE up to now, it is still listed among the top upgrades for the ISOLDE facility at CERN. The first dedicated low-energy storage ring is being commissioned at GSI. This is the CRYRING which is built behind the ESR.

In this contribution, recent experiments that have been performed at ESR and CSRe will be discussed. As an outlook, the perspectives of future experiments at the existing storage ring facilities as well as at the planned facilities will be outlined.

[1] J. Glorius *et al.*, Phys. Rev. Lett. (2019) *in press*.

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