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Nuclear physics program at the ESR storage ring

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Abstract

This talk presents a survey of experiments conducted in the last years at the ion-storage ring ESR of GSI, addressing nuclear physics, nuclear astrophysics and closely related fields. The ESR is a powerful and in many respects unique tool. Connected with a synchrotron and a fragment separator, it provides stable as well as exotic highly-charged ions in an energy range from a few MeV/u up to 400 MeV/u. Those beams exhibit a tiny relative momentum spread $\Delta p/p < 10\text{-}6$ after the application of stochastic and electron cooling, and can be stored for extended periods of time (~ hours). Moreover, this ring offers for heavy, highly-charged ions the capability of single-ion detection within a very short time. These properties, together with sophisticated in-ring devices, such as a windowless gas target, collinear laser beams and Schottky-noise detectors, open up the very first access to several precision experiments in the fields of nuclear physics and neighbouring research fields on the one hand, and to the investigation of very rare processes on the other hand. The focus of this talk will be on the following topics:
· Precision measurements of masses and lifetimes of nuclei far off stability, e.g. in the rp- and r-process regions of stellar nucleosynthesis, by exploiting two complementary detection methods, namely "Schottky"(SMS)- and "Isochronous"(IMS)- Mass Spectrometry.
· Studies of beta decay and, in particular, of two-body beta decay (orbital electron capture and bound-state beta decay) of few-electron ions by means of "single-ion decay spectroscopy", where the "fate"of single beta-unstable ions, being prepared in well-defined quantum states, is monitored continuously.
· Collinear laser spectroscopy addressing e.g. the ground-state hyperfine splitting of heavy few-electron ions, which gives precise information on nuclear magnetization and quantum-electro-dynamic (QED) corrections.
· Di-electronic recombination providing access to nuclear charge radii (see also special talk).
· Proof of principle of in-ring nuclear reactions of exotic nuclei (see also special talk).
A broad research program concerning in-ring nuclear reactions of exotic nuclei is not yet possible due to the present limitation of the intensity of stored exotic ions. However, when the approved FAIR facility at GSI will come into operation, exotic beams with many orders of magnitude higher intensity can be safely expected.

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