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Recent Upgrades of the Penning-trap Mass Spectrometer SHIPTRAP for High-precision Mass Measurements

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Penning-trap mass spectrometry allows direct and reliable measurements of atomic masses with very high precision. This technique is especially suitable to investigate the nuclear structure evolution of radioactive nuclides through measurements of binding energies.
The heaviest elements investigated to date in pioneering experiments with the SHIPTRAP setup at GSI, Darmstadt, have been nobelium and lawrencium [1,2]. The existence of such heavy nuclei is intimately connected to nuclear shell effects that stabilize them against spontaneous fission. The direct measurement of the masses of {252−255}^No and {255,256}^Lr has allowed mapping the strength of the deformed subshell closure at N=152.
In order to extend such studies to heavier and more exotic nuclides, the efficiency, precision and sensitivity of the SHIPTRAP setup is being further increased [3]. In particular, a cryogenic buffer gas-stopping cell [4] has been recently commissioned and the whole SHIPTRAP setup has been relocated on a 3-degree beam line at the SHIP (Separator for Heavy Ion reaction Products) recoil separator, in preparation for future online campaigns aiming at direct mass measurements of elements beyond Lr.
To this end, the novel Phase-Imaging Ion-Cyclotron-Resonance technique (PI-ICR) [5], recently developed at SHIPTRAP, will be applied for the first time to the region of the heaviest elements. This new method allows mass measurements with only a few ion counts, i.e. at the lowest production yields. In addition, it reaches an accuracy level of 10^{-9}, even for short-lived nuclides ($T_{1/2} \leq 1$s).
Such high precision is required in the context of neutrino physics, another field of SHIPTRAP activities, for instance in $Q_{\beta/EC}$ measurements [6]. Q-values with uncertainties of few eV are demanded in experiments that aim at the determination of the neutrino mass (hierarchy) or the search for neutrinoless double-β decays.
This contribution will present an overview of the recent results of the measurements related to the neutrino physics as well as the present status of the SHIPTRAP setup.

References:
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