Contribution ID: **63** Type: **Poster**

Towards Higher-Precision Mass Spectrometry of Rare Isotopes with ISOLTRAP

Monday, 25 November 2013 18:10 (1h 20m)

One of the main goals of modern experimental nuclear physics is studying exotic nuclides far from the valley of stability of the nuclear chart. Measuring the mass of these nuclides allows gaining knowledge about the nuclear forces keeping nuclides bounded and about the resulting nuclear structure. ISOLTRAP is the Penning-trap mass spectrometer situated at ISOLDE-CERN used for high-precision measurements of the masses of radioactive ions [1, 2].
The Time-of-Flight Ion-Cyclotron-Resonance (ToF-ICR) technique is used at ISOLTRAP for cyclotron-frequency measurements. It has been successfully used for measuring the mass of ions with yields as low as 102 ions/μC and half-lives as short as tens of milliseconds with relative uncertainties of 10-8 [1]. Exotic nuclides with often lower half-life and minute production rates combined with high ratios of contaminating ions pose enormous challenges. Moreover, studies related to neutrino physics or fundamental interactions often require mass measurements with lower uncertainties than the ones presently achievable [3, 4]. Different developments are thus ongoing at the ISOLTRAP setup to obtain higher precision.
Recently introduced, the Phase-Imaging Ion-Cyclotron-Resonance (PI-ICR) method [5] is a promising approach to gain the higher precision. It consists in directly measuring the frequencies of the radial eigenmotions of the trapped ion by determining the evolution of the ions'radial phase, accumulated during a certain amount of time. An enhancement in precision of a factor of 5 and in resolving power of a factor of 40, as compared to the ToF-ICR technique, has already been demonstrated at SHIPTRAP [5]. Also, the PI-ICR technique is up to 25 times faster than the ToF-ICR technique. Thus, it allows investigating more exotic nuclides.
After refurbishment, the systematic uncertainties of the ISOLTRAP setup are being determined. For example, the mapping of the magnetic field has been performed to aim at minimizing its systematic influence. This contribution will briefly report on the current status of the ISOLTRAP setup, present ongoing studies for improving the achievable precision for measurements, and set the stage for an implementation of the PI-ICR detection technique.
References
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Session Classification: Poster Session