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High-accurcay Penning trap mass measurements for nuclear structure and fundamental studies[1]

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Like few other parameters, the mass of an atom, and its inherent connection with the atomic and nuclear binding energy is a fundamental property, a unique fingerprint of the atomic nucleus. For short-lived exotic atomic nuclei the importance of its mass ranges from the verification of nuclear models, nucleosynthesis studies, to a test of the Standard Model, in particular with regard to the weak interaction and the unitarity of the Cabibbo-Kobayashi-Maskawa quark mixing matrix [1]. The introduction of Penning traps into the field of mass spectrometry has made this method a prime choice for high-accuracy measurements on short-lived and stable nuclides. This is reflected in the large number of traps in operation, under construction, or planned world-wide. With the development and application of proper cooling and detection methods the trapping technique has the potential to provide the highest sensitivity and accuracy, even for very short-lived nuclides far from stability. The limits of mass measurements of exotic nuclei have been extended considerably by improving and developing on-line Penning trap mass spectrometers as, e.g., CPT at Argonne, ISOLTRAP at ISOLDE/CERN, JYFLTRAP at IGISOL/Jyväskylä, LEBIT at MSU/East Lansing, and SHIPTRAP at GSI/Darmstadt. The precise determination of nuclear binding energies far from stability includes nuclei that are produced at rates of 100 ions/s and with half-lives well below 100 ms. The mass resolving power reaches 10^7 and the uncertainty of the resulting mass values has been pushed down to below 10^{-8}. The presentation will describe the basics and recent progress made in ion trapping, cooling, and detection for high-accuracy Penning trap mass measurements. Special attention is devoted to the applications of accurate mass values for nuclear structure and fundamental studies. [1] K. Blaum, Phys.Rep. 425 (2006) 1.

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