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Ultra-high precision nuclear mass measurements for fundamental studies

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The four fundamental interactions and their symmetries, the fundamental constants as well as the properties of elementary particles like masses and moments, determine the basic structure of the universe and are the basis for our so well tested Standard Model (SM) of physics. Performing stringent tests on these interactions and symmetries in extreme conditions at lowest energies and with highest precision by comparing, e.g., the properties of particles and their counterpart, the antiparticles, will allow us to search for physics beyond the SM. Any improvement of these tests beyond their present limits requires novel experimental techniques.

An overview is given on recent mass measurements with extreme precision on single exotic ions stored in Penning traps. Among others the most stringent test of bound-state quantum electrodynamics could be performed, the accuracy of the electron and proton atomic mass got improved significantly, and precision nuclear masses contributed to neutrino physics research. Most recently even applications in dark matter searches opened up where relative mass uncertainties at the level of 10⁻¹¹ and below are required.

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