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Ultra-precise mass measurements for fundamental studies

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The Penning-trap mass spectrometer PENTATRAP [1] located at the Max Planck Institute for Nuclear Physics in Heidelberg is able to determine mass-ratios of highly charged ions of long-lived nuclides with a relative uncertainty of a few ppt [2, 3]. With a broad measurement program PENTATRAP did and continues to contribute to several fields of physics, e.g. test of bound-state QED [2] with direct measurements of binding energies and meta stable electronic states, neutrino-physics [3] and test of special relativity [4] by determining Q-values of nuclear reactions and 5th force research [5,6] with mass-ratios of isotope chains. Achieving ppt-precision requires a cryogenic ion trapping system in a stabilized, cold-bore 7 T superconducting magnet as well as applying image-current detection systems with single-ion phase-sensitive detection methods. Highly charged ions provided by external ion sources increase detector signal-to-noise as well as measurement precision due to higher frequencies. Simultaneous measurements in two traps allow for direct crosschecks of systematic effects. Presented will be the latest results and the status of the experiment.

[1] Repp, J. et al., Appl. Phys. B 107, 983 (2012).
[2] Schüssler, R.X. et al., Nature 581, 42–46 (2020).
[3] Filianin, P. et al., Phys. Rev. Lett. 127, 072502 (2021).
[4] Rainville, S. et al., Nature 483, 1096 (2005).
[5] Counts, I. et al., Phys. Rev. Lett. 125, 123002 (2020).
[6] Rischka, A. et al., Phys. Rev. Lett. 124, 113001 (2020).

Scientific topic

Application of new technologies

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