High-Precision Measurement of the Proton's Atomic Mass

Fabian Heiße[a,b], Sascha Rau[a], Florian Köhler-Langes[a], Jiamin Hou[a], Sven Junck[c], Anke Kracke[a], Andreas Mooser[d], Wolfgang Quint[b], Stefan Ulmer[d], Günter Werth[c], Klaus Blaum[a] and Sven Sturm[a]

[a] *Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany*
[b] *GSI Helmholtzzentrum für Schwerionenforschung, D-64291 Darmstadt, Germany*
[c] *Institut für Physik, Johannes Gutenberg-Universität Mainz, D-55099 Mainz, Germany*
[d] *RIKEN, Ulmer Fundamental Symmetries Laboratory, Wako, Saitama 351-0198, Japan*

The electron, the proton and the neutron are the basic building blocks of the visible universe. The precise knowledge of their properties is of great interest for tests of fundamental physics and metrology.

To measure the proton's mass in atomic mass units, a new cryogenic fivefold Penning-trap setup was constructed, which is termed LIONTRAP (Light ION TRAP). It is the successor experiment of the former g-factor experiment for highly charged ions, which provided the most stringent tests of bound-state QED [1, 2, 3]. Moreover, it delivered the most precise value of the atomic mass of the electron [4].

The measurement principle is based on a phase-sensitive comparison of the proton's cyclotron frequency to that of a carbon nucleus ($^{12}C^{6+}$). To accomplish high precision a purpose-built doubly compensated Penning trap was set up, consisting of seven cylindrical electrodes. These electrodes serve to produce an extremely harmonic quadrupole trapping field by canceling out higher order electric field contributions using properly chosen voltages.

With a relative precision of 32 parts per trillion our result improves the current literature value by a factor of 3 and reveals a disagreement of about 3 standard deviations to it [5]. Additionally, the result affects the puzzle of light ion masses [6], but is not enough to explain the mass discrepancy of 4 standard deviations. At this conference, the new LIONTRAP setup as well as the latest results on the proton's atomic mass and the next major upgrades are presented.

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