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High-precision measurement of the electron mass and stringent tests of BS-QED with highly-charged ions

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High-precision measurements of the gyromagnetic factor (g-factor) of the electron bound in highly-charged ions have provided the most stringent tests of bound-state Quantum electrodynamics (BS-QED) to date [1,2] as well as the most precise determination of the electron mass [3].
In our experiment, a single highly-charged ion is produced and stored in a triple-Penning trap system which is placed in a hermetically sealed vacuum chamber. Cryogenic temperatures enable an ultra-high vacuum and thus nearly unlimited storage times for the ion. The measurements are performed with a single ion, whose three eigenfrequencies are measured in the homogenous magnetic field of the Penning trap. By employing a self-developed phase-sensitive detection technique [4], the modified cyclotron frequency of the ion can be measured at very low energies. Simultaneously to the measurement of the eigenfrequencies, spin flips are induced by microwaves at the Larmor precession frequency. Successful spin flips are monitored with the continuous Stern-Gerlach effect. From several hundred measurements of the frequency ratio of Larmor to cyclotron frequency, a resonance curve is obtained from which the g-factor can be extracted with a fractional statistical uncertainty as low as 3·10-11.

[1] S. Sturm et al., Phys. Rev. Lett. 107, 023002 (2011)
[2] A. Wagner et al., Phys. Rev. Lett. 110, 033003 (2013)
[3] S. Sturm et al., Nature 506, 467 (2014)
[4] S. Sturm et al., Phys. Rev. Lett. 107, 143003 (2011)

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