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Direct high-precision measurement of the magnetic moment of the proton[1]

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The challenge to measure the properties of the proton with great precision inspires very different branches of physics. The magnetic moment of the proton is a fundamental property of this particle. So far it has only been measured indirectly, by analyzing the spectrum of an atomic hydrogen maser in a magnetic field. Here we report the direct high-precision measurement of the magnetic moment of a single proton using the double Penning-trap technique. We drive proton-spin quantum jumps by a radio-frequency field in a Penning trap with a homogeneous magnetic field. The induced spin transitions are detected in a second trap with a strong superimposed magnetic inhomogeneity. This enables the measurement of the spin-flip probability as a function of the drive frequency. In each measurement the proton's cyclotron frequency is used to determine the magnetic field of the trap. From the normalized resonance curve, we extract the particle's magnetic moment in terms of the nuclear magneton: $\mu_\mathrm{p} = 2.792\,847\,350\,(9)\,\mu_\mathrm{N}$. This measurement outperforms previous Penning-trap measurements in terms of precision by a factor of about 760. It improves the precision of the forty year-old indirect measurement by D. Kleppner et al., in which significant theoretical bound-state corrections were required to obtain μ_p, by a factor of 3. By application of this method to the antiproton magnetic moment, the fractional precision of the recently reported value can be improved by a factor of at least 1,000. Combined with the present result, this will provide a stringent test of matter/antimatter symmetry with baryons.

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