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Most Precise Determination of the Fine Structure Constant: Electron g and QED

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Currently, the most accurate determination of the fine structure constant comes from our measurement of the electron magnetic moment in Bohr magnetons, $g/2 = 1.001\ 159\ 652\ 180\ 73(28)$ [0.28 ppt][1]. This measurement utilized quantum jump spectroscopy of transitions between the lowest quantum levels of a one-electron quantum cyclotron. The single trapped electron itself served as a precise magnetometer to allow for greater accumulation of quantum-jump line shape statistics. The spontaneous emission rate of the single electron at multiple values of the magnetic field was used to correct for the interaction between the electron and a cylindrical cavity, used to inhibit spontaneous emission by about a factor of 200. This measurement, combined with QED theory and small additional standard model corrections yields $\alpha^{-1} = 137.035\ 999\ 084(51)$ [0.37 ppb]. Improvements to the QED theory, to be reported in this session, will allow us to report a slightly shifted value of the fine structure constant with a slightly reduced uncertainty.

A new trap, now in operation, is designed to use cavity-sideband cooling to cool the axial motion of a single electron in a Penning trap to near its quantum ground state. The new apparatus also contains a positron source which should allow a greatly improved comparison of the magnetic moments of the positron and electron as a test of CPT invariance. Additionally, the completely new apparatus is designed to reduce the effect of vibrations and thermal fluctuations. Progress toward improved measurements of both the electron and positron magnetic moments will be summarized.

[1]D. Hanneke, S. Fogwell, and G. Gabrielse, Phys. Rev. Lett. 100, 120801 (2008)