Abstract

We propose to measure the parity-violating asymmetry A_{PV} in the scattering of longitudinally polarized 11 GeV electrons from the atomic electrons in a liquid hydrogen target (Møller scattering). In the Standard Model, A_{PV} is due to the interference between the electromagnetic amplitude and the weak neutral current amplitude, the latter being mediated by the Z^0 boson. A_{PV} is predicted to be 35.6 parts per billion (ppb) at our kinematics. Our goal is to measure A_{PV} to a precision of 0.73 ppb. The result would yield a measurement of the weak charge of the electron Q^e_W to a fractional accuracy of 2.3% at an average Q^2 of 0.0056 (GeV/c)^2.

In the Standard Model, the Q^e_W measurement yields a determination of the weak mixing angle $\sin^2\theta_W$ with an uncertainty of $\pm 0.00026(\text{stat}) \pm 0.00013(\text{syst})$, similar to the accuracy of the single best such determination from high energy colliders. Thus, our result could potentially influence the central value of this fundamental electroweak parameter, a critical input to deciphering signals of any physics beyond the Standard Model that might be observed at the Large Hadron Collider (LHC).

In addition, the measurement is sensitive to the interference of the electromagnetic amplitude with new neutral current amplitudes as weak as $\sim 10^{-3} \cdot G_F$ from as yet undiscovered high energy dynamics, a level of sensitivity that is unlikely to be matched in any experiment measuring a flavor and CP-conserving process over the next decade. This provides indirect access to new physics at multi-TeV scales in a manner complementary to direct searches at the LHC. Some examples of potential new physics effects for which our measurement extends sensitivity beyond current and planned low energy measurements include new Z' bosons, electron compositeness, supersymmetry and doubly charged scalars.