Searching for Physics Beyond the Standard Model with Parity-Violating Møller Scattering

Krishna Kumar,
University of Massachusetts, Amherst, MA 01003.

Abstract

The study of parity-violating electron scattering has become a precision tool to probe a variety of fundamental questions in nuclear and particle physics. In such experiments, one measures the fractional difference (under polarization reversal) in the cross-section for the scattering of longitudinally polarized beam electrons off unpolarized fixed targets. A non-zero asymmetry is a signature of parity-violation, and is due to the interference between the weak neutral current and electromagnetic amplitudes.

Parity-violating Møller scattering is a particularly clean way[1] to access the weak neutral current amplitude with little theoretical uncertainty[2], facilitating a search for new neutral current interactions at the TeV scale[3], in a manner complementary to high energy collider measurements. The recently completed SLAC E158 experiment has demonstrated the feasibility of the technique and established the running of the weak mixing angle as a function of Q^2 to more than 6 standard deviations[4].

Significantly improved measurements are possible at future facilities. After Jefferson Laboratory is upgraded to 12 GeV, it is possible to contemplate a measurement[5] of the weak mixing angle with a precision comparable to the two best high energy measurements: A_{LR}(SLD) and A_{FB}(b-quarks). The latter two measurements disagree by more than 3 standard deviations and lead to very different conclusions about the implications for new high energy physics[6].

In the far future, parity-violating Møller scattering might well lead to the world's best single future measurement of the weak mixing angle at a fixed target facility as part of the International Linear Collider. Such a measurement would yield a weak mixing angle measurement with accuracy that is significantly better than the current world average and comparable in precision to the best possible measurements at high energy scales at future colliders[7].

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