CEBAF EXPERIMENT 91-004

Parity-Violating Elastic Scattering from ^{4}He

E. Beise, Spokesperson

The issue of whether strange quarks contribute significantly to hadronic structure has been the focus of much recent theoretical discussion. These strange matrix elements are accessible through the neutral weak form factors, which can be directly measured in parity-violating electron scattering. At CEBAF, three experiments have been proposed to make complementary measurements of strangeness matrix elements in hadronic matter. The experiment described here makes use of the fact that in scattering from a J=0, T=0 target only one strange matrix element can contribute, the strange electric moment.

Parity violating electron scattering is evaluated in terms of the asymmetry in the cross section for right- and left-helicity electrons from an unpolarized target. The asymmetry is proportional to the ratio of the neutral weak and electromagnetic response functions:

$$A = \frac{d\sigma_R - d\sigma_L}{d\sigma_R + d\sigma_L} = \frac{G_F Q^2}{\pi a \sqrt{2}}\, x\, \frac{R^Z}{R^\gamma}$$

The neutral weak response function can be rewritten in terms of isoscalar and isovector electromagnetic response functions, plus an additional term due to strange quarks.

$$R^Z = \left(\frac{1}{2} - \sin^2\theta_W\right) R^\gamma_{T=1} - \sin^2\theta_W R^\gamma_{T=0} - \frac{1}{4} R^S.$$

In the J=0, T=0 hadronic system, there are only two independent form factors: $R^\gamma_{T=0}$ and R^S. Parity-violating elastic scattering from a nucleus such as ^{4}He reduces to

$$A = \frac{G_F Q^2}{\pi a \sqrt{2}}\left[\sin^2\theta_W + \frac{1}{4}\frac{R^S}{R^\gamma_{T=0}}\right].$$

Any deviation of the asymmetry from $\sin^2\theta_W$ is either an indication of isospin violation or a measure of strange quark effects. In a light nucleus such as ^{4}He, isospin violations are expected to be quite small, so a large effect will be due to the presence of strange quarks. In a simple model (the impulse approximation plus lowest order meson exchange currents), the charge form factor $R^\gamma_{T=0}$ is described by a product of nucleon form factors and a distribution function representing the nuclear structure. In the ratio $R^S / R^\gamma_{T=0}$ the nuclear structure will cancel and what remains is a ratio of nucleon form factors, giving a measure of the strange form factor of the nucleon, G_E^S.

CEBAF E-91-004 is a measurement of ^{4}He (e,e') at Q^2 = 0.6 (GeV/c)^2. The experiment will use the pair of 4 GeV/c high resolution spectrometers in Hall A, each with a solid angle of ~7 msr. The target will be a circulating ^{4}He gas system operating at 10K and 70 atm, with a 15 cm target cell. At the highest CEBAF design luminosity (~3.2 x 10^{38}), the counting rate into each spectrometer is ~2 kHz so the "standard" detector package of the spectrometers will be used to detect electrons. The asymmetry with no strange quarks is 5 x 10^{-5}, large on the scale of parity-violating experiments. Although few models for the Q^2dependence of G_E^Scurrently exist, the presence of s-quark effects could change this value by more than 200%, possibly even changing the sign of the asymmetry. Thus, even a measurement with moderate statistical precision could significantly constrain the size of the strange quark contributions.