THE ELECTRIC FORM FACTOR OF THE NEUTRON FROM THE $D(\vec{e},e'\vec{n})p$ REACTION

Abstract

We propose to determine the electric form factor G_E^n of the neutron by scattering longitudinally-polarized electrons from deuterium quasielastically and measuring the transverse polarization component $p_{S'}$ of the recoil neutron. The neutron polarization component $p_{S'}$, which lies in the scattering plane normal to the neutron momentum, is directly proportional to G_E^n in the impulse approximation. The neutron is detected in coincidence with the scattered electron. The experiment is based on a neutron polarimeter provided by Kent State University and a liquid-deuterium (LD) target capable of dissipating about 400 watts. A prototype (7 cm) LD target at MIT can handle an average beam current of 50 μA. Based on a (6/88) test run at Bates, the neutron polarimeter is expected to operate satisfactorily with a luminosity of 3×10^{38} $cm^{-2}s^{-1}$ at CEBAF.

The uncertainties in the best available measurements of G_E^n as a function of Q^2 are too large to distinguish between form factor models and not even between $G_E^n = 0$ and $G_E^n = -\tau G_M^n$ when the Dirac form factor $F_{1n} = 0$; however, the proposed experiment is designed to make these distinctions. The expected uncertainties ΔG_E^n are small fractions of the uncertainties in published data (from quasieleastic scattering of electrons from deuterium). Preliminary design considerations indicate that G_E^n can be measured as a function of Q^2, the four-momentum transfer squared, up to about 1.5 $(GeV/c)^2$ with a statistical uncertainty of $\pm$ 0.005 in the transverse polarization of the recoil neutron for four values of Q^2 in the range $0.30 \leq Q^2\ (GeV/c)^2 \leq 1.1$ and a statistical uncertainty of $\pm$0.010 for two additional points at Q^2 = 0.15 and 1.5 $(GeV/c)^2$. Except for the lowest Q^2 point, statistical uncertainties in the neutron polarization propagate to an uncertainty ΔG_E^n in G_E^n of typically $\pm$ 0.016 for $G_E^n = -\tau G_M^n$ and $\pm$ 0.01 or less for $G_E^n = 0$.

A theoretical study by Arenhövel (1987) indicates that the transverse polarization of the recoil neutron has almost no dependence on the deuteron model, and is insensitive to the influence of final-state interactions, meson-exchange currents, and isobar configurations.