CEBAF EXPERIMENT 93-038

The Electric Form Factor of the Neutron from the $d(\vec{e}, e'\vec{n})p$ Reaction

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CEBAF Experiment 93-038 addresses a fundamental question regarding the nature of the charge structure of the neutron - one of the two basic building blocks of matter: What is the spatial distribution of the constituent quarks within the neutron? This question is addressed in this experiment by scattering longitudinally polarized electrons quasielastically from a neutron in deuterium. Deuterium consists of a neutron and a proton bound loosely together; it represents the best neutron target available. In a collision with the neutron, the electron transfers its polarization to the neutron. Both components of the neutron polarization lie in the scattering plane: The sideways component $P_{S'}$ is normal to the momentum of the neutron, and the longitudinal component $P_{L'}$ is parallel (or antiparallel) to the neutron momentum. By measuring both the sideways and the longitudinal polarizations $P_{S'}$ and $P_{L'}$, respectively, it is possible to extract G_E^n from the ratio of the associated asymmetries $\xi_{S'}/\xi_{L'}$, which is independent of the average analyzing power $< A_y >$ of the neutron polarimeter and the polarization P_L of the electron beam. Measurement of $\xi_{L'}$ requires a dipole magnet ahead of the polarimeter to process $P_{L'}$ to a sideways orientation. Measurements of G_E^n as a function of the squared four-momentum transfer Q^2 are related to the spatial distribution of the charge within the neutron.

Knowledge of G_E^n is essential to understanding the structure of matter. G_E^n is a fundamental quantity needed for detailed microscopic calculations of electromagnetic nuclear structure functions, for testing the evolving constituent quark models of particle structure, and for extraction of the strangeness factors from parity violating (e, e') experiments. Current knowledge of the neutron electric form factor is insufficient to meet these needs. Results from early efforts to measure G_E^n suffered from sensitivities to models of deuteron structure. CEBAF E93-038 will utilize a neutron detector[1] designed specifically to measure the scattering asymmetry from the transverse polarization component of the neutron. The neutron is detected in coincidence with the scattered electron. The electron is detected in a magnetic spectrometer. A special advantage of this experiment is that the interpretation of the results of the neutron polarization measurement is insensitive to theoretical models involving the structure of the deuteron, as shown first by Arenhoevel[2].

The continuous electron beam at CEBAF will provide an advantage of about 125 over the the pulsed-beam operation used for the pioneering Bates experiment[E85-05]. CEBAF E93-038 offers the opportunity to obtain a model insensitive measurement of the neutron electric form factor with small uncertainties. This experiment will provide a clear response to the challenge set forth by the report of the Nuclear Science Advisory Committee (SAC) that the "electromagnetic structure of the neutron...stands as a significant challenge for experimentalists." CEBAF E93-038 addresses one of the three primary scientific goals of CEBAF (viz., to elucidate the quark and gluon structure of the proton and the neutron).

[1] R. Madey, A. Lai, T. Eden: Proc. of the 11th International Symposium on Polarization in Nuclear Physics, American Institute of Physics, (1995).

[2] H. Arenhoevel, Phys. Lett. **B199**, 13 (1987).