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The Neutron Magnetic Form Factor from Precision Measurements of the Ratio of Quasielastic Electron-Neutron to Electron-Proton Scattering in Deuterium

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Nucleon structure is one of the most fundamental issues in nuclear physics. Elastic electron scattering provides detailed information about the electromagnetic structure of the nucleon. The differential cross section for elastic electron-nucleon scattering in the one-photon-exchange approximation is given by the Rosenbluth formula [1] in which the nucleon structure information is contained in the Sachs electric and magnetic form factors. These form factors are used for comparison between experiment and theoretical models of nucleon structure. In addition to being of fundamental importance in understanding nucleon structure, the form factors are a necessary input for calculations of nuclear response functions.

Although the proton form factors are well determined, the present knowledge of the neutron form factors is inadequate to impose severe constraints on nucleon structure models. Reliable separations of the two form factors have been made up to Q^2 = 9 $(GeV/c)^2$ for the proton, but only to Q^2 = 4 $(GeV/c)^2$ for the neutron [2]. Also, the neutron form factors have been determined with much less precision than those of the proton [2]. The reason for the large uncertainties in the neutron measurements is that most of these data come from analyses of inclusive quasielastic electron scattering from deuterium that introduce a number of significant systematic errors.

In this experiment, precise measurements of the ratio of quasielastic electron-neutron to electron-proton scattering in deuterium will be made over a Q^2 range from 0.3 to 7.5 $(GeV/c)^2$ with the CLAS. The neutron magnetic form factor will be extracted from this ratio with the use of the more accurately known proton form factors. Data will be taken simultaneously on separated hydrogen and deuterium targets. The $e+p \rightarrow e+n+\pi^+$ reaction on the hydrogen target will be used to measure the neutron detection efficiency. The data from electron-proton and electron-neutron scattering in deuterium will be treated in an identical way insofar as possible. The use of this ratio technique, with the simultaneous calibration of the neutron detection efficiency, significantly reduces or eliminates many of the systematic errors associated with quasielastic scattering from deuterium. The results of this experiment will provide a significant improvement in our knowledge of the neutron magnetic form factor over the Q^2 coverage of existing measurements, and will nearly double the range. In addition to providing accurate information on the magnetic structure of the neutron, these data will be important for the extraction of the electric form factor of the neutron from future measurements of polarization observables which determine a linear combination of the electric and magnetic form factors.

[1] M.N. Rosenbluth, Phys. Rev. **79**, 615 (1950).
[2] P.E. Bosted, Phys. Rev. **C51**,409 (1995); and references therein.