CEBAF EXPERIMENT 93-027

G_{Ep} by Recoil Polarization Method

The understanding of the structure of the nucleon is of fundamental importance; ultimately such an understanding is necessary for the first principle description of the nuclear force. Also, an interesting problem is related to the question: do the nucleons in a nucleus have the same properties as free nucleons? or does the very close presence of other nucleons in the nucleus change the nucleon size, shape and magnetic moment The electromagnetic probe, either real photons or the virtual photons associated with the scattering of electrons, is sensitive to the distribution of charges and currents inside the scattered, be it a single nucleon or a nucleus. Furthermore, real or virtual photons interact directly with the quark constituents of the nucleon, a most propitious situation for the study of the quark degrees of freedom in nuclei.

The standard method of analysis of the differential cross section for elastic scattering of an electron by the nucleon is based on the Rosenbluth formula:

$$\frac{d\alpha}{d\Omega_e} = \frac{d\alpha}{d\Omega_{Mott}}[G_E^2(Q^2) + \tau G_M^2[1+2(1+\tau)\tan^2(\frac{\theta_e}{2})]] = \frac{d\alpha}{d\Omega_{Mott}} I_0$$

where G_E and G_M are the Sachs electric and magnetic form factors of the nucleon, $Q^2 = q_\mu{}^2$ is the 4-momentum transfer squared, $\tau = {}^2/4M$, with M the nucleon mass, and θ_e is the electron laboratory scattering angle. In eqn. above $d\sigma/d\Omega_{Mott}$ is the Mott cross section for a point charge. The Scahs form factors fully characterize the charge and current distribution inside the nucleon as long as the probing is elastic, that is without emission of mesons. A complete description of the electromagnetic structure of the nucleon requires measurement of the form factors G_E and G_M for both the proton and the neutron.

A recent determination at SLAC, of the <u>magnetic form factor G_{mp} for the proton</u> has reduced the uncertainties to $\leq \pm 0.01$ for G_{mp}. For the <u>electric form factor</u> of the proton the experimental uncertainties vary from 0.05 to 0.20 over the range of Q^2 of interest, and results of various experiments are not consistent within error. Experiment 93-027 at CEBAF will reduce these uncertainties to the range of 0.015-0.035; it will use for the first time the recoil polarization method. The elastic scattering of longitudinally polarized electrons on the proton results in a polarization of the recoil proton, with only two components P_t/P_1, transverse and longitudinal in the reaction plane, respectively. Measuring P_t/P_1 gives directly the ratio G_{Ep}/G_{Mp}. This method gives G_{ep} as an interference term, and P_tP_1 are measured simultaneously, thus greatly decreasing possibilities of systematic errors.

The proton polarization will be measured in the Hall A focal plane polarimeter presently under construction at WM and Rutgers. In a polarimeter the recoil protons are scattered in a thick graphite bloc and the azimuthal distribution of the scattering protons is measured. An important byproduct of this experiment will be the calibration of the analyzing power of the polarimeter.

The PAC6 has approved this experiment to measure G_{ep} in the range Q^2=0.5 to 3.5 GeV^2 in steps of 0.5 GeV^2. Extension of this experiment to Q^2=6 GeV^2 will become possible with a 6 GeV beam.