Measurement of the Neutron Electric Form Factor G_E^n at High Q^2

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1 Summary

E02-013 is an experiment to measure the electric form factor of the neutron, G_E^n, at high values of Q^2. In the Breit–frame, G_E^n is the Fourier transform of the charge distribution of the neutron. As such it is one of the most fundamental ingredients in a description of the electromagnetic structure of the neutron. Our knowledge of G_E^n is rather poor, however, compared to our knowledge of the other electromagnetic form factors of the proton and neutron. The reasons for this are twofold. Firstly, there are no free neutron targets on which to perform experiments. Secondly, the standard method of using a Rosenbluth separation is very demanding, because $\tau G_M^n \gg G_E^n$ so the magnetic form factor dominates the cross section. E02-013 answers these issues by using polarization degrees of freedom. Specifically, E02-013 will measure quasi-elastic scattering in the process $^3\vec{\mathrm{He}}(\vec{e}, e'\,\mathrm{n})$.

The scientific motivation to measure G_E^n at high values of Q^2 is at present particularly compelling. Recent measurements at JLab demonstrated that the ratio G_E^p/G_M^p decreases in a roughly linear fashion at high Q^2. In simple terms, the observation indicates that the distribution of charge and magnetic currents in the proton are different from one another. Theoretical analysis of the results appear to indicate that relativistic effects and orbital angular momentum within the nucleon must play a more important role than was initially anticipated. There are now several predictions for the neutron, and the results of E02-013 are likely to help distinguish between them. Thus, in addition to characterizing a fundamental property of the neutron, E02-013 will likely shed light on some broad issues concerning the structure of the nucleon.

In E02-013, we will measure the neutron electric form factor at three values of Q^2, ranging from 1.3 $(GeV/c)^2$ to 3.4 $(GeV/c)^2$, with the point at lower Q^2 overlapping with previous measurements. We expect to achieve a statistical uncertainty in $\Delta G_E^n\ /G_E^n$ of 0.14 in each of three data points assuming G_E^n follows the Galster parameterization and 768 hours of beam time. The experiment will access the neutron electric form factor through a measurement of the cross section asymmetry in the scattering of longitudinally polarized electrons off of a polarized helium-3 target. The scattered electrons will be detected in the new Bigbite spectrometer and the recoiling neutrons will be detected in the "Big Hall A neutron detector", or "BigHand".