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Measurement of the Spin-Dependent Asymmetry in Quasielastic Electron Scattering from Polarized Tritium

C.E. Jones, Spokesperson

For a given choice of nuclear potentials the physical observables of two- and three-body nuclear systems can be calculated exactly, making comparisons of theoretical predictions with experimental measurements of ^{2}H, ^{3}H and ^{3}He especially important for a complete understanding of nuclear dynamics. Although much electron scattering data for ^{2}H and ^{3}He has been collected. to date most of the experiments have used unpolarized beams and targets and few have used tritium targets.

Measurements of the spin observables in the A=3 system are needed for a complete understanding of the three body system. Calculations based upon the ground state wave functions of ^{3}H and ^{3}He suggest that the proton primarily carries the nuclear spin of tritium and the neutron primarily carries the spin of ^{3}He. Because the proton's electromagnetic form factors are experimentally known to a precision of 5%, a comparison of ^{3}H quasielastic asymmetry data with three-body calculations is subject to less uncertainty from the underlying nucleon properties than measurements of quantities that depend strongly upon the relatively poorly known neutron electric form factor. Experimental data on polarized tritium will serve to better constrain calculations of the three-body system which include reaction processes such as final state interactions and meson exchange currents. In addition, measurements of the tritium quasielastic asymmetry can test whether the proton form factors are modified in the nuclear medium. Studies of the polarization of the proton in tritium will not only serve as a benchmark for testing theoretical predictions of electron scattering spin observables in the three-body system, but may well be a necessary step in extracting the neutron form factors from experiments using polarized ^{3}He.

A measurement of both the transverse and longitudinal asymmetries and the unpolarized cross sections in $^3\vec{H}(\vec{e},e')$ quasielastic scattering at Q^2 = 0.23, 0.50, and 0.80 (GeV/c)^2 is proposed. The experiment will use longitudinally polarized electrons of energy 0.96 - 1.90 GeV and a polarized tritium target based upon the principle of spin exchange with optically-pumped polarized potassium atoms. The target requires only 1 Curie of tritium fore a target thickness of 2x10^{17}/cm^2. One advantage of the polarization mechanism employed is that a mixture of hydrogen and tritium can be used in the target, so that elastic scattering from hydrogen will serve as a continuous and simultaneous polarization monitor and cross section normalization throughout the experiment. The quasielastic tritium asymmetries will be measured to a statistical precision of ΔA/A = 4 - 7% with systematic uncertainties of ~ 7%. These measurements are of sufficient accuracy to serve as a benchmark for theoretical calculations of the spin observables in the three-body system. Initial beam tests will be done using ^{1}H to prove the viability of the target with a nonradioactive gas.