Measurement of the Parity Violating Asymmetry in the $N \to \Delta$ Transition

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The parity violating asymmetry measured in inclusive electron scattering reactions is driven by the exchange of a Z^0 boson, which can be exploited to probe hadronic structure. This feature has been the focus of much recent attention for elastic parity violating electron asymmetry measurements, both experimentally and theoretically, as a means for determining the contribution from strange quarks to ground state nucleon properties [1, 2, 3, 4]. Specifically, if isospin is taken to be a good symmetry, then parity violating elastic electron proton scattering directly probes the strange vector current matrix element $\langle p|\bar{s}\gamma_\mu s|p\rangle$, allowing for a determination of the nucleon strange charge and magnetic form factors, G_E^s and G_M^s. Experiments of this type are now technically quite feasible [5]. If parity violating electron nucleon scattering experiments are extended beyond the elastic channel into particular inelastic channels, additional information about the nucleon quark currents can clearly be obtained. Due to the pure isovector nature of the $N \to \Delta$ transition, the parity violating asymmetry in electroproduction of this resonance can isolate the isovector contributions to these currents [6, 7, 8, 9]. In particular, the axial vector transition form factor $G^A_{N\Delta}(Q^2)$, which has also been a topic of much recent experimental and theoretical interest [10, 11, 12, 13, 14], is isovector in nature, and can be directly accessed through the parity violating asymmetry in the $N \to \Delta$ transition.

What is intriguing about the $N \to \Delta$ asymmetry measurements is that they provide direct access to $G^A_{N\Delta}$, and represent the first determination of this form factor in the neutral current sector of the weak interaction. In addition, this new physics has the distinct advantage that much of it will obtained with minimal addition to existing apparatus, and with no additional beam time. In the TJNAF PAC approved G0 experiment [1], the parity violating asymmetry in elastic $\vec{e}+p$ scattering will be measured in two different modes of running. The superconducting toroidal spectrometer used for these measurements will be oriented in two directions: one for the detection of the forward scattered protons, and the other for the backward scattered electrons. Both configurations are necessary for the separation of G_E^s and G_M^s from the $\vec{e}+p$ elastic asymmetry measurements. In addition to the Focal Plane Detectors (FPD's), a set of detectors mounted at the exit of the G0 cryostat (Cryostat Exit Detectors) is required for the separation of the elastic and inelastic channels during the backward angle measurements. The coincidences between these two sets of detectors serve the dual purpose of eliminating the inelastic contamination from the elastic measurements, and allow the parity violating asymmetry to be mapped out across the Δ resonance simultaneously. The asymmetry in the $N \to \Delta$ transition is expected to be approximately the same size as that in elastic $\vec{e}+p$ scattering [8], and the inelastic yield is much larger but spread out kinematically; thus, similar statistical precision will be obtained for the inelastic asymmetry as for the elastic asymmetry during the same running period.

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