CEBAF Experiment 94-117

Helicity Structure of Pion Photoproduction on Polarized Deuteron and the GDH Sum Rule for the Neutron

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We propose to measure the difference of the helicity-$\frac{1}{2}$ and -$\frac{3}{2}$ contributions to single and two pion photoproduction cross sections on the neutron at energies between 0.28 GeV and 2.2 GeV using circularly polarized tagged photons and the CLAS detector. Simultaneously, total photoabsorption cross sections for both helicity states will be obtained from an inclusive hadron production measurement. We will scatter from the bound neutron in a novel polarized solid HD target. In this target, either hydrogen, deuterium or both can be polarized and there is only 5% extraneous unpolarized material by weight. The reduced backgrounds expected from such a pure target make it possible to measure absolute cross sections as well as asymmetries.

A model independent partial wave analysis requires a vigorous experimental program of meson photoproduction. The experimental observables expressible in terms of helicity amplitudes are the differential cross section, the recoil polarization, the photon and target asymmetries and the double polarization observables. By choosing proper combinations of the polarizations for the double polarizations observables, one can make a set of measurements completely determining the seven helicity amplitudes describing pseudoscalar meson photoproduction in a model independent way. There are only scarce double polarization data on the proton and no data at all exist on the neutron. Data from our experiment will add an essential part to the complete set of measurements needed to determine the helicity amplitudes.

At the same time, helicity asymmetries from double pion photoproduction will provide a new tool to study those resonances with large branching ratios to two pion decay channels and relatively small ratios to single pion channels. Several baryon resonances predicted by constituent quark models[1] have not yet been seen. These quark models suggest that these "missing" states have a very small decay branch to πN states (escaping the analysis of single pion production data) yet possess a sufficiently large photocoupling constant to be detected in multipion final states.

The inclusive measurements will allow a direct experimental test of the GDH sum rule[2]. This unsubtracted sum rule follows from the dispersion relation for forward Compton scattering and the optical and low energy theorems. Estimates derived from existing (mostly unpolarized) data differ from the sum rule values by up to 30-40%. The generality of the underlying assumptions suggest very strongly that the sum rule should be directly verified. All measurements will be performed nearly identically to and consecutively with the approved proton measurement, E-91-015. Results on the neutron can be extracted by subtracting the proton cross sections from those of the deuteron. These results, combined with the measurement from pion threshold up to 470 MeV at LEGS will allow a direct experimental test of the GDH sum rule for the neutron up to 2.2 GeV. Most of the resonance contributions, which are expected to dominate the sum rule, lie below 2 GeV.

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