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Proton Polarization Angular Distribution in Deuteron Photodisintegration

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Deuteron photodisintegration has been a focus for recent experimental searches for a clear breakdown in meson-baryon descriptions of nuclei and nuclear reactions at high energy and momentum transfer, as a signature of a transition to quark physics. Cross-section data up to 4 GeV for angles from 37 to 90°_{cm} are qualitatively described within a variety of models. The constituent counting rules, which can be derived from pQCD, work at large angles, but the small-angle cross sections agree with the Regge-theory quark-gluon string model. The entire data set is qualitatively reproduced by the QCD rescattering model, which relates photodisintegration to nucleon-nucleon scattering, the quark-exchange model, which reduces to an effective nuclear model, and the asymptotic meson-exchange model.

E89-019 measured the first recoil proton polarization in $D(\gamma, p)n$ at high energies, at 90°_{cm} for $E_\gamma \approx 0.5$ to 2.5 GeV. The induced polarization P_y and polarization transfers C_x and C_z were determined. P_y disagrees dramatically with the highest-energy old data, for $E_\gamma \approx 0.8$ - 1.0 GeV, and with the Bonn meson-exchange calculation.

The Bonn calculation is the most complete meson-exchange calculation, including π, ρ, η, and ω exchange, plus all well established nucleon and Δ resonances with $m < 2$ GeV and $J \leq 5/2$. The calculations qualitatively reproduce the $D(\gamma, p)n$ cross section and polarization data up to nearly 1 GeV. The cross sections are well described up to 1.6 GeV, the limit of the calculation, but the description of P_y totally breaks down. Indeed, above 1 GeV P_y seems entirely consistent with the pQCD prediction. These observations suggest the onset of quark physics near 1 GeV.

Given these surprising results, we have proposed to measure an angular distribution at $E_\gamma \approx 2$ GeV. By taking advantage of the CH_2 analyzer upgrade proposed for the G_E^P/G_M^P extension, E99-007, we are able to measure each angle in about 2 days. Due to the rapid fall of the cross sections with energy, 2 GeV is about the highest energy at which an angular distribution may be obtained in reasonable time. Anticipated uncertainties are about ± 0.05 for P_y and C_x, but somewhat larger for C_z due to unfavorable spin transport.