E94-010:Measurement of the Netron (3He) Spin Structure Function at Low Q^2: a connection between the BJ and DHG sum rules

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The nucleon spin has been of central interest ever since the EMC experiment found that at high Q^2 quarks carry only a small fraction of the nucleon spin. The Bjorken sum rule, which relates the deep inelastic scattering spin structure function at high Q^2 to the nucleon axial coupling constant, was tested in the last 20 years of spin structure experiments at high energy laboratories. At the other extreme, $Q^2 = 0$, there is another fundamental sum rule, the Gerasimov-Drell-Hearn (GDH) sum rule, which relates the nucleon spin structure to its anomalous magnetic moment. The GDH sum rule is based on very general principles and is valid not only for the nucleon but also for any nucleus.

How does the spin structure evolve with Q^2 (especially at low Q^2) and what is the connection between the GDH and the Bjorken sum rules? Recent theoretical developments in the generalization of the GDH sum rule, based on the same general assumptions as the GDH sum rule, provides the framework for understanding and answering the above questions. The GDH and the Bjorken sum rules are the two limiting cases, at $Q^2 = 0$ and $Q^2 = \infty$, of the generalized GDH sum rule. The generalized GDH sum rule has been calculated at small Q^2 with Chiral Perturbation Theory and calculations have also been done for high Q^2 with higher order QCD (twist) expansions. The transition from the high Q^2 (pQCD region, quark-gluon picture) regime to the low Q^2 (non-perturbative region, coherent hadron picture) regime may be calculated in the future with lattice QCD calculations. This will provide, for the first time, the possibility that hadron structure can be described by a fundamental theory in the entire kinematic regime.

Experimental tests of the generalized GDH sum rule have only recently become possible. This experiment, E94-010, measures the spin structure and the generalized GDH sum for the neutron with a polarized ^{3}He target. Data were successfully taken from September to December 1998 at a fixed scattering angle of 15.5° at six diffrent beam energies ranging from 0.86 to 5.1 GeV. The Q^2 range is from 0.03 to 1.1 GeV^2. The energy transfer range is from elastic to 3 GeV, covering the quasielastic, resonance and the deep-inelastic regions. Data analysis is underway. This experiment is the first one to measure the neutron and ^{3}He spin structure functions and the generalized GDH sum at low to intermediate Q^2. It is also the first one to successfully use a polarized ^{3}He target at JLab, setting the stage for a program to study the neutron and ^{3}He spin structure.