SANE – Spin Asymmetries on the Nucleon Experiment 03-109

The large x region is fascinating because it provides a window on proton structure in a regime where the sea quarks have been stripped away. One may hope that simple models can be applied to these "naked protons", potentially leading to insights into strong QCD complementary to those obtained a generation ago from Constituent Quark Model descriptions of the baryon mass spectrum. Nucleon spin asymmetries at large x may not only yield clues about $SU(6)$ (spin-flavor) symmetry breaking in confinement QCD, but are essential for the determination of all but the first moment of the spin structure functions. These moments are the natural connection between experiment and Lattice QCD, since Lattice calculations do not directly determine spin observables like A_1^p but only the lowest several moments of the various polarized and unpolarized parton distribution functions (PDF's).

Lattice QCD collaborations hope to begin calculating the moments of these PDF's with near-physical pion masses in the next few years employing Teraflop·Year computing resources. Results are available today using 0.1 Teraflop·Year computations which unfortunately require significant extrapolations to the chiral limit. However, the paucity of accurate data at high x means that there will generally be significant ambiguities in relating spin structure function (SSF) observables to Lattice QCD moments. One certain way to remove this ambiguity is with precise data at large x. Unfortunately, the probability of finding a single quark with a large fraction of the nucleon's longitudinal momentum is small, so large x measurements are often not merely statistics-limited but statistics-starved. An important exception are the three A_1^n points from Hall A, which clearly show for the first time that A_1^n at large x is non-zero and rising.

Although the world dataset for A_1^p is in better shape than that of A_1^n, the trend of the data in the limit $x \to 1$ is not clear, and is completely inadequate for estimating all but the first moment of A_1^p. The situation is even worse for A_2^p and the related g_2^p SSF. However, a thorough program of A_1^p and A_2^p measurements at large x, including tests of the W dependence, would consume thousands of hours of beam time using traditional techniques.

A new experiment (E03-109) that will address those constraints with a revolutionary increase in Figure of Merit for making high x SSF measurements has been conditionally approved by PAC24 with A- rating. The experiment is called SANE (**S**pin **A**symmetries on the **N**ucleon **E**xperiment), and is based on a 194 msr electron detector viewing the UVa polarized nucleon target operating at $8.5 \cdot 10^{34}$ proton-luminosity. SANE will take data for 654 hours to make precise DIS measurements of A_1 and A_2 on the proton for x to 0.63. The data will also be used to test whether, or to what accuracy, suitably averaged measurements in the resonance region reproduce the DIS result for A_1^p (i.e., so-called "spin duality"). If spin duality obtains it would be possible to determine A_1^p to x as large as 0.80.

The g_2 SSF has twist-2 (from g_1) and twist-3 components, which can be separated with a precision measurement of g_2 for $x > 0.3$. The third moment of the twist-3 part is proportional to the twist-3 d_2 matrix element that represents quark-gluon interactions and has been calculated in Lattice QCD, QCD sum rules and other models. The SANE g_2^p measurement will extract d_2^p with unprecedented precision at several values of $Q^2 < 6$ GeV/c^2 for a conclusive determination of this fundamental quantity. Only SANE is capable of such result at the proposed kinematics.