Highlights of Recent Spin Physics Results from STAR

Jae D. Nam, for the STAR collaboration

The unique capability of the Relativistic Heavy Ion Collider (RHIC) to collide polarized protons provides an ideal testing ground for exploring a wide range of topics in spin physics. This, along with the excellent coverage and particle identification provided by the STAR detector, has opened new avenues for investigating the proton spin structure.

This overview talk will encompass recent highlights from the STAR experiment. It will begin with investigations into unpolarized parton densities, establishing robust procedures for reconstructing various observables measured at STAR. Measurements of inclusive jet production investigate unpolarized gluon density and provide proper tuning for simulations. Weak bosons ($W^{\pm}/Z$) reconstructed from their decay leptons can be used to probe the sea quark ($\bar{u}$ and $\bar{d}$) densities.

The talk will then delve into explorations of the longitudinal spin structure of the proton. Longitudinal double spin asymmetries, A_{LL}, of inclusive and dijet events provide access to gluon helicity distribution, supplemented by measurements of A_{LL} with charged hadrons within jets. Furthermore, the longitudinal single spin asymmetries, A_L, of $W^{\pm}$ bosons probe the sea quark helicity contribution, clearly demonstrating asymmetric contribution of the $\bar{u}$ and $\bar{d}$ quarks to the proton spin.

The largely unknown transverse spin structure of the proton will be explored next. Spin-dependent shifts in the azimuthal separation between two jets in a dijet event can be used to extract the initial state parton transverse momentum. The transverse single spin asymmetry, A_N, of $W^{\pm}/Z$ bosons reconstructed from the leptonic decay channel pins down the transverse partonic motion to the initial state and tests the non-universality of the Sivers effect. Additionally, the A_N of charged hadrons within jets can be used to probe quark transversity and investigate the universality of fundamental TMD functions. The dihadron A_N provides an independent measurement of quark transversity in the collinear framework. Measurements of A_N of diffractive processes investigate the contribution of these processes to the unexpectedly large A_N in the forward ($2.5 < \eta < 4$) regime.

Finally, prospects for the recent STAR data-taking periods, with enhanced forward tracking and calorimetry delivered by the STAR forward upgrade, will be discussed.