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Transverse spin and transverse momentum structure of the nucleon from the COMPASS experiment

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The description of the partonic structure of the nucleon is one of the central problems of hadronic physics. In recent years considerable theoretical and experimental progress has been made and the relevance of the quark transverse spin and transverse momentum has been clearly assessed. In the present theoretical framework, eight transverse momentum dependent parton distribution functions (TMD PDFs) are required at leading twist for each quark flavor. They describe all possible correlations between the transverse momentum and spin of the quarks, and the spin of the nucleon. When integrating over the quark transverse momentum five of these functions vanish, while three of them give the well known number, helicity and transversity distribution functions. Among these last three functions, the transversity distribution, which is the analogous of the helicity PDFs in the case of transversely polarized nucleons, was thoroughly studied only in the 90s and experimentally it is the least known one. On the experimental side, several complementary processes are being, and will be, studied to access the TMD PDFs, namely transversely polarized hard proton-proton scattering, Drell-Yan processes, and semi-inclusive deeply inelastic lepton scattering (SIDIS). This last channel is today the major source of information. It allows to access easily convolutions of the different TMD PDFs and fragmentation functions via high statistic measurements of asymmetries in the azimuthal distributions of the final state hadrons. Also, using different (p, d, or n) targets and identifying the final state hadrons, one can separate the contributions of the quarks of different flavor. The clear non-zero spin asymmetries recently measured in SIDIS off transversely polarized targets by both HERMES at DESY and COMPASS at CERN at different beam energies, can be described quite well with the present formalism, and thus give much more confidence in the overall picture.

COMPASS (COmmon Muon and Proton Apparatus for Structure and Spectroscopy) is a fixed target experiment at the CERN SPS taking data since 2002. An important part of the experimental programme consists in the study of the nucleon structure and SIDIS data have been collected using a 160 GeV longitudinally polarized muon beam and longitudinally or transversely polarized proton (NH_3) and deuteron (^{6}LiD) targets. From all these data several measurements related to the transverse structure of the nucleon have been performed, and the aim of this talk is to give a summary of the COMPASS contribution to the field. A selection of the results on the azimuthal asymmetries measured from the data collected with transversely polarized targets is presented, with particular focus on the most recent measurements from the data collected in 2007 and 2010 with the proton target. These results exhibit clear signals for the Collins asymmetry, interpreted as a convolution of a non-zero transversity PDF and Collins fragmentation function, and for the Sivers asymmetry which is related to the Sivers function, the most famous and discussed of the TMD PDFs. The comparison with the HERMES results at lower beam energy gives insights in the Q^2 evolution of the TMD functions. The data collected with the ^{6}LiD target, suitably mixed up to cancel possible target polarization effects, have also been analysed to search for the azimuthal modulations in the production of hadrons which are expected to be present in the SIDIS cross-section. The azimuthal hadron asymmetries, which are related to the Boer-Mulders TMD PDF, show strong and somewhat puzzling kinematical dependencies.