# Poincaré covariance and the relativistic description of SiDIS by a polarized $^3$ He target

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A realistic study of the semi-inclusive deep inelastic scattering (SiDIS) by polarized targets, like $^3\vec{H}e(\vec{e}, e'\pi)X$ is of primary importance in view of the forthcoming high luminosity experiments, planned at Thomas Jefferson National Accelerator Facility for extracting transversity parton distributions inside the neutron [1].

As it is well known, the quark polarizations take into account at most one-third of the nucleon polarization. This motivates the great effort on both experimental and theoretical sides to elucidate such an issue, and to accurately determine the contributions from the quark orbital angular momentum ($L_q$) and the gluons.

Information on the so-called quark transverse-momentum distributions (TMDs), and in turn on $L_q$, can be accessed through non-forward processes, like SiDIS. To study TMDs in a transversely polarized neutron, an ideal target is a transversely polarized $^3He$ target, since at 90% level it is equivalent to a polarized neutron target.

Our aim is to study the SiDIS process $^3He(e, e'\pi)X$ in the actual experimental kinematics [1] with a proper care of relativistic effects. In view of that, we present a novel *fully Poincaré covariant description* of the nuclear target [2], implementing a Light-Front (LF) analysis at finite $Q^2$, within the Bakamijan-Thomas construction of the Poincaré generators (see [3,4] for a presentation of the approach in the Bjorken limit). The main ingredient of our approach is the LF spin-dependent spectral function for a J=1/2 system [2], fully determined by three independent scalar functions.

Furthermore, the final-state interaction between the jet produced from the hadronizing quark and the two-nucleon spectator system will be included through a Glauber approach [5]. The present study extends previous, non Poincaré covariant, investigations of the SiDIS process $^3\vec{H}e(\vec{e}, e'\pi)X$, which were carried out within the impulse approximation in the Bjorken limit [6], and suggests a novel tool for accessing the nuclear structure, in analogy to the approach based on TMDs of the quarks inside the nucleon.

Our Poincaré covariant analysis for a J=1/2 three-body system can be also applied for the description of the particle contribution to the *nucleon quark-quark correlator*. Indeed the contribution to the nucleon correlation function from on-mass-shell fermions can be straightforwardly expressed through the LF spin-dependent spectral function [2]. Therefore the *nucleon quark-quark correlator* depends only on three independent scalar functions. As a consequence, within our LF approach with a fixed number of degrees of freedom, the six T-even leading-twist TMDs result to be expressed in terms of only three independent scalar functions. Therefore, in the approximation where only the valence component of the nucleon is considered, exact linear relations between the six T-even leading-twist TMDs can be obtained [2]. These relations are completely new and could be experimentally checked to test the validity of the LF description of SiDIS in the valence region.


[1] TJLab experiments E12-09-018 and E12-10-006, web page: http://hallaweb.jlab.org/12GeV/

[2] A. Del Dotto, E. Pace, M. Rinaldi, G. Salmè and S. Scopetta, to be published.

[3] S. Scopetta, A. Del Dotto, E. Pace and G. Salmè, "Transversity studies with a polarized $^3He$ target", IL NUOVO CIMENTO, **C35**, 101 (2012); "Quark Transverse Momentum Distributions inside a nucleon : a Light-Front Hamiltonian Dynamics study", Acta Physica Polonica **6**, 103 (2013), DOI:10.5506/APhysPolBSupp.6.1001.

[4] A. Del Dotto, E. Pace, M. Rinaldi, G. Salmè and S. Scopetta, "Neutron Transverse-Momentum Distributions and Polarized $^3$He within Light-Front Hamiltonian Dynamics", arXiv 1301.5787 and Few-Body Syst. (2013), DOI:10.1007/s00601-013-0679-0, in press.

[5] L. Kaptari, A. Del Dotto, E. Pace, G. Salmè and S. Scopetta, " Distorted spin-dependent spectral function of $^3$He and semi-inclusive deep inelastic scattering processes ", JLAB-THY-13-1732.

[6] S. Scopetta, "Neutron single spin asymmetries from semi-inclusive deep inelastic scattering off transversely polarized 3He", Phys. Rev. **D 75** 054005 (2007).