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EMC effect, few-nucleon systems and Poincare' covariance

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Traditional nuclear physics regards the nucleus as being composed of bound nucleons and mesons. This picture has had significant success in describing the properties of nuclei across the chart of nuclides. However, the fundamental theory of the strong interaction is QCD, where quarks and gluons are the elementary degrees of freedom. Deep inelastic scattering experiments have long suggested that a nucleon-meson based picture of the nucleus is incomplete. Indeed the observation of the EMC effect [1] has provided an indication for explicit QCD effects in nuclei.
The EMC effect is the observation that the parton distribution functions (PDFs) for nuclei are different than the incoherent sum over the PDFs of the constituent nucleons and suggested that the structure of the nucleons may be different when bound together in a nucleus. Since the original discovery in 1983, there has been a large program of measurements at several laboratories, such as CERN, Fermilab, SLAC, DESY, and Jefferson Lab (JLab), aimed at understanding the properties and probing the origin of the nuclear dependence of inelastic structure functions, covered in detail in several reviews [2,3,4,5].
Since the first observation of the EMC effect, many theoretical models have been proposed and can be subdivided into two categories. One takes care only of "traditional"nuclear physics effects, using convolution models including binding effects with spectral functions corresponding to realistic two- and three-body nuclear interactions. The other category invokes more exotic explanations, such contributions of six or nine quark bags, or medium modification of the internal structure of the nucleons such as "nucleon swelling"or suppression of point-like nucleon configurations.
Our work points to merge "traditional"nuclear physics in a Poincare' covariant framework through a Poincare' covariant spin-dependent spectral function [6,7,8]. It is based on the light-front (LF) Hamiltonian dynamics [9, 10] and is a useful tool for a correct relativistic treatment of nuclear structure, suitable for the study of deep inelastic scattering (DIS) or semi-inclusive deep inelastic scattering (SIDIS) processes at high momentum transfer [11,12,13]. Indeed the Bakamjian-Thomas construction [14] of the Poincare' generators allows one to embed the successful phenomenology for few-nucleon systems in a Poincare' covariant framework. In particular we study the 3He nucleus and our preliminary results for the EMC effect in 3He will be presented.
The LF spectral function for a three-fermion system, as the 3He, depends on the energy ε of the spectator subsystem and on the LF momentum $\varkappa$ of the knocked out particle in the intrinsic reference frame of the (particle - spectator pair) cluster. It is built up from the overlaps of the ground eigenstate of a proper mass operator for the system [6,7,8] and the tensor product of a plane wave for the particle times the fully interacting state for the spectator. The use of the momentum $\varkappa$ allows one to take care of macrocausality [9] and to introduce a new effect of binding in the spectral function. The LF spectral function fulfills normalization and momentum sum rule at the same time.
We aim to provide for the first time a Poincare' covariant calculation of the nuclear part of the EMC effect for the trinucleon system (both 3He and tritium), so that one can safely investigate genuinely QCD-based effects, as effects of non-nucleonic degrees of freedom or modifications of nucleon structure in nuclei, needed for reconciling experimental results and theoretical description.

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