Nuclear effects in $g_{1A}(x, Q^2)$ at small x in deep inelastic scattering on ^{3}He and ^{7}Li [1]

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Abstract

We suggest to use polarized nuclear targets of ^{3}He and ^{7}Li for studying nuclear effects in the nuclear spin dependent structure functions $g_{1A}(x, Q^2)$. These effects are expected to be enhances as compared to the unpolarized targets. We predict a significant x dependence at $10^{-3} \leq x \leq 0.2$ due to effects of nuclear shadowing and antishadowing. The effect of nuclear shadowing is of an order of 10% for ^{3}He and 15% for ^{7}Li. By imposing the requirement that the Bjorken sum rule satisfies we model the effect of antishadowing. We find the effect of antishadowing to be of an order of 25% for ^{3}He and 35% for ^{7}Li.

Nuclear shadowing and antishadowing are the two fenomena that modify the structure functions of nuclei at low x. Although all previous studies of the Bjorken sum rule for nuclei have ignored them. We suggest to study experimentally these effects on polarized nuclei of ^{3}He and ^{7}Li because nuclear shadowing and antishadowing are larger by a factor of **two** as compared to the unpolarized targets [1].

Nuclear shadowing occurs at $10^{-4} \leq x \leq 0.05 \div 0.1$ Using the generalized Glauber formalism we obtain for the ratio of the spin dependent structure functions of ^{3}He and a neutron

$$\frac{g_{1^3He}(x, Q_0^2)}{g_{1n}(x, Q_0^2)} = \frac{\sigma_T^+(e^3He) - \sigma_T^-(e^3He)}{\sigma_T^+(en) - \sigma_n^-(en)} = 1 - \frac{\sigma_{eff} exp(-\alpha q_{\|}^2)}{4\pi(\alpha+\beta)} + \frac{\sigma_{eff}^2}{48\pi^2(\alpha+\beta)^2} \ . \quad (1)$$

[1] Talk given at the preworkshop *Hard QCD Phenomena at TJNAF 8+*, TJLab, June 14 1998.

Here superscripts + or − stand for parallel (antiparallel) helicities of the incoming photon and the target nucleus (neutron). α=27 GeV^{-2} is the slope of a nuclear one-particle density chosen to reproduce the e.m. form factor of ^{3}He. β=6 GeV^{-2} is the slope of the hadron-nucleon cross section. σ_{eff}=17 mb which corresponds to a replacement of the sum over hadronic components of the photon by a single term with the typical mass $M_h = Q^2$. $q_{\|} = \frac{Q^2+M_h^2}{2\nu} = 2m_N x$ is the nonvanishing longitudinal momentum transferred to the target in the transition $\gamma \to h$.

Numerically, for example at $x \leq 0.03$ Eq. (1) gives $1 - g_{1^3He}(x,Q^2)/g_{1n}(x,Q^2) = 0.1$ which is by a factor of two larger than the unpolarized case.

The presence of shadowing violates the Bjorken sum rule

$$\frac{\int_0^1 [g_1^{^3He}(x,Q^2) - g_1^{^3H}(x,Q^2)]dx}{\int_0^1 [g_1^n(x,Q^2) - g_1^p(x,Q^2)]dx} = \eta(^3\mathrm{He}) \ , \qquad (2)$$

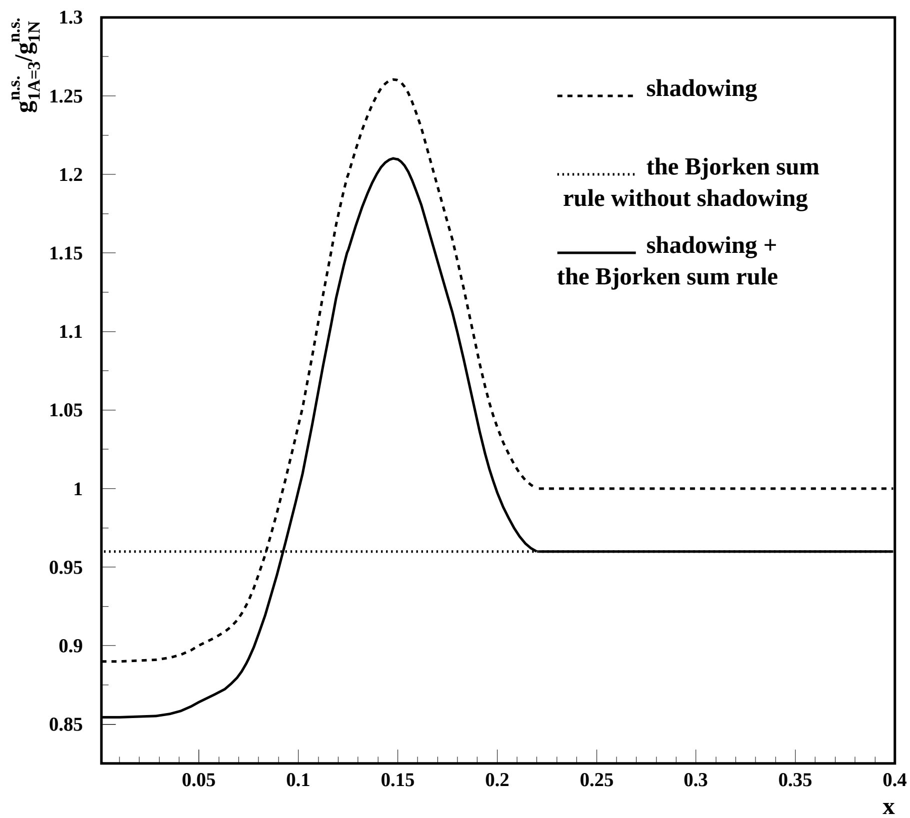
where $\eta(^3\mathrm{He})$=0.963.

We suggest to model antishadowing such that its contribution to the Bjorken sum rule compensates the contribution of shadowing

$$\int_{.001}^{.2} dx(g_1^{^3He}(x,Q^2) - g_1^{^3H}(x,Q^2)) = \int_{.001}^{.2} dx(g_1^n(x,Q^2) - g_1^p(x,Q^2)) \qquad (3)$$

We present our results in Fig. 1 [1]. The dotted straight line represents the Bjorken sum rule within the impulse approximation corrected to include higher partial waves and nonnucleonic degrees of freedom in the ground state wave function of ^{3}He. We assume that the discussed effects contribute multiplicatively which shifts the dotted curve for shadowing downward. Our prediction for $g_{1A=3}^{n.s.}/g_{1N}^{n.s.}$ is given by the solid line.

Therefore we predict a nontrivial x dependence of $g_{1^3\mathrm{He}}/g_{1n}$ at small x: 10% shadowing for $10^{-4} \leq x \leq 0.03$ and antishadowing of an order of 25% for $x \approx 0.15$.



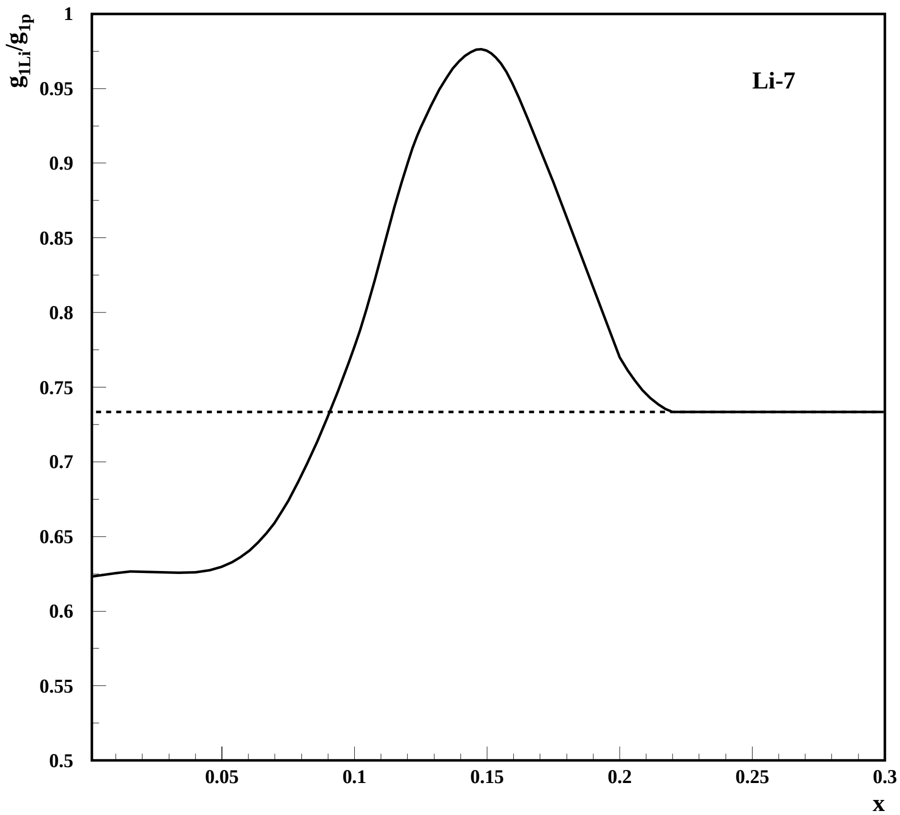
Quite similarly, using the generalized Glauber formalism and the shell model ground state wave function of ^{7}Li [2] we can present the ratio of the spin dependent structure functions

$$\frac{g_1^{Li}(x,Q^2)}{g_1^p(x,Q^2)} = \frac{\Delta\sigma^{Li}}{\Delta\sigma(p)} = \frac{11}{15}(1 - 1.38\frac{\sigma_{eff}F(x)}{\pi(R^2+3\beta)} - 0.31\frac{\sigma_{eff}F(x)}{\pi R^2}) \quad (4)$$

Here $R^2 = 5.7$ fm^2, σ_{eff}=17 mb, $\beta = 6$ GeV^{-2} and $F(x) = exp(-\frac{1}{3}(q_{\|}R)^2)$. We obtain

$$\frac{g_1^{Li}(x,Q^2)}{g_1^p(x,Q^2)} = \frac{11}{15}(1 - 0.15\,exp(-176 \cdot x^2)) \quad (5)$$

Eq. (5) is our main result for deep inelastic scattering on polarized ^{7}Li. It predicts 15% shadowing of $g_{1^7Li}(x,Q^2)/g_{1p}(x,Q^2)$ for $x \leq 3 \cdot 10^{-3}$. We predict 35% antishadowing by imposing the requirement that its contribution to the Bjorken sum rule cancels the contribution of shadowing. Our prediction for the ratio $g_{1^7Li}(x, Q_0^2)/g_{1p}(x, Q_0^2)$ as a function of x is presented in Fig. 2.



References

[1] L. Frankfurt, V. Guzey and M. Strikman, Phys. Lett. **B 381** (1996) 379

[2] L.D. Landau and E.M. Lifsitz "Quantum mechanics, non relativistic theory", Pergamon Press 1977