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Linearly polarized gluon density in the rescaling model

N. A. Abdulov[+], *X. Chen*[*×], *A. V. Kotikov*[+1)], *A. V. Lipatov*[+◦]

[+]*Joint Institute for Nuclear Research, 141980 Dubna, Russia*

[*]*Institute of Modern Physics, Chinese Academy of Sciences, 730000 Lanzhou, China*

[×]*School of Nuclear Science and Technology, University of Chinese Academy of Sciences, 100049 Beijing, China*

[◦]*Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, 119991 Moscow, Russia*

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Determination of parton (quark and gluon) distribution functions (PDFs) in a proton and nuclei is a rather important task for modern high energy physics. In particular, detailed knowledge on the gluon densities is necessary for experiments planned at the Large Hadron Collider (LHC) and future colliders, such as Electron-Ion Collider (EIC), Future Circular hadron-electron Collider (FCC-he), Electron-Ion Collider in China (EicC) and Nuclotron-based Ion Collider fAcility (NICA) [1–6]. For unpolarized cases, there are a distribution of unpolarized gluons, denoted as $f_g(x, Q^2)$, and a distribution of linearly polarized gluons $h_g(x, k_t^2, Q^2)$, which corresponds to interference between ± 1 gluon helicity states[2)]. Compared to $f_g(x, Q^2)$, function $h_g(x, k_t^2, Q^2)$ is currently poorly known[3)] in comparison with $f_g(x, Q^2)$ and depends on the gluon transverse momentum k_t (so called Transverse Momentum Dependent, or TMD gluon density). A theoretical upper bound for $h_g(x, k_t^2, Q^2)$ was obtained [7, 8].

Previously, we have derived an analytical expression for linearly polarized gluon density in a proton and investigated its behavior at low x [9]. Our analysis was based on the small-x asymptotics for sea quark and gluon densities calculated in the generalized *double asymptotic scale* (DAS) approach [10–14] (see also [15]) and was done with leading order (LO) accuracy. In the present note we extend the consideration [9] for nuclei.

We follow the rescaling model [16–18] based on the assumption [19, 20] that the effective size of gluon and quark confinement in the nucleus is greater than in the free nucleon. Within the perturbative QCD, it was pointed out [16–20] that this confinement rescaling predicts that nPDFs and PDFs can be connected by simply scaling the argument Q^2 (see also a review [21]).

Initially, the rescaling model was proposed for the domain of valence quarks dominance, $0.2 \leq x \leq 0.8$, where x is the Bjorken variable. Recently it was extended to a small x [22–24], where certain shadowing and antishadowing effects[4)] were found for the sea quark and gluon densities. Our main goal is to apply the rescaling model to linearly polarized gluon density $h_g(x, k_t^2, Q^2)$ and show its nuclear modification for small x values.

We found that the nuclear modification of linearly polarized gluon density is quite similar to the one of conventional gluon density, but polarized gluons are less affected by nuclear effects. So that, the derived expressions could be useful for subsequent phenomenological applications.

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1) e-mail: kotikov@theor.jinr.ru

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3) See also recent review [6].

4) The investigations of shadowing and antishadowing effects (see [25–28] and [27, 28], respectively) have been started even before experimental data [29, 30] were appeared (see [31–33] for an overview).

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