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# QCD ANALYSIS FOR NUCLEAR PARTON DISTRIBUTIONS IN THE NEXT TO LEADING ORDER

S. Atashbar Tehrani and Ali N. Khorramian
Physics Department, Semnan university, Semnan, Iran;
Institute for Studies in Theoretical Physics and Mathematics (IPM),
P.O.Box 19395-5531, Tehran, Iran

**Abstract**

A QCD analysis of the nuclear parton distributions and structure functions in the NLO is performed by using the world data. By having bounded parton distributions for a nuclear with atomic number A, we can obtain the nuclear structure function in x space. Our results for nuclear structure function ratio $F_2^A/F_2^D$ for some different values of A, are in good agreement with the experimental data. We compare our results for LO and NLO approximation.

## 1 Introduction

Parametrization of nuclear parton distributions is investigated in the next–to–leading order (NLO) of $\alpha_s$. Unpolarized parton distributions in the nucleon are now well determined in the region from very small $x$ to large $x$ by using various experimental data. Initial distributions are assumed at a fixed $Q^2$ with parameters which are determined by a $\chi^2$ analysis. In this work we used the MRST parametrization [1] as the input parton distributions in the nucleon. In Ref. [2] a LO QCD analysis was performed and authors applied the MRST parton distributions [3] in the nucleon. Until now much efforts have been done to compute the nuclear parton densities and structure functions in the perturbative QCD [2, 4–8]. In this paper after parametrization of nuclear parton distributions in $Q_0^2 = 4$ GeV$^2$, we will obtain the nuclear structure function ratio $F_2^A/F_2^D$ for helium, carbon and calcium nuclei in the LO and NLO.

## 2 Nuclear Structure Function

Our analysis is done in the next–to–leading order of $\alpha_s$. According to parton model the nuclear structure function $F_2^A$ in the NLO is given by [9]

$$\begin{aligned}\frac{1}{x}F_2^{eA}(x,Q^2) &= \sum_{q=u,d,s} e_q^2 \left\{ q^A(x,Q^2) + \overline{q}^A(x,Q^2) + \frac{\alpha_s(Q^2)}{2\pi} \right.\\ &\quad \left. \times \left[ c_{q,2} \otimes (q^A + \overline{q}^A) + 2c_{g,2} \otimes g^A \right] \right\} , \end{aligned} \quad (1)$$

where $e_q$ is the quark charge, and $q^A(\overline{q}^A)$ is the quark (antiquark) distribution in the nucleus $A$. Here the sum expands over all light quarks $q = u,\ d,\ s$ and $c_{q,2}$, $c_{g,2}$ are as following

$$\begin{aligned} c_{q,2} &= \frac{4}{3}\left[\frac{1+z^2}{1-z}\left(\ln\frac{1-z}{z} - \frac{3}{4}\right) + \frac{1}{4}(9+5z)\right]_+ \\ c_{g,2} &= \frac{1}{2}\left[\left(z^2+(1-z)^2\right)\ln\frac{1-z}{z} - 1 + 8z(1-z)\right] . \end{aligned} \quad (2)$$

The convolutions are defined as

$$c \otimes q = \int_x^1 \frac{dy}{y} c\left(\frac{x}{y}\right) q(y,Q^2) . \quad (3)$$

Notice that

$$\int_x^1 \frac{dy}{y} f\left(\frac{x}{y}\right)_+ g(y) = \int_x^1 \frac{dy}{y} f\left(\frac{x}{y}\right)\left[g(y) - \frac{x}{y}g(x)\right] - g(x)\int_0^x dy f(y) . \quad (4)$$

In this paper we assumed the flavor symmetric antiquark distribution, $\overline{u}^A = \overline{d}^A = \overline{s}^A \equiv \overline{q}^A$. We consider also the nuclear parton distributions as

$$u_v^A = \mathcal{W}_{u_v}\frac{Z\ u_v + N\ d_v}{A}, \quad d_v^A = \mathcal{W}_{d_v}\frac{Z\ d_v + N\ u_v}{A}, \quad \overline{q}^A = \mathcal{W}_s\ \overline{q}, \quad g^A = \mathcal{W}_g\ g, \quad (5)$$

in the above equations, we suppose the functional form for the weight function for all partons as

$$\mathcal{W}_i = 1 + \left(1 - \frac{1}{A^{1/3}}\right)\left(\frac{a_i + b_i\ x + c_i x^2 + d_i\ x^3}{(1-x)^{e_i}}\right) . \quad (6)$$

After using the MRST parton distributions in the nucleon at $Q_0^2$=4 GeV$^2$ we can be able to determine some unknown parameters which appear in the

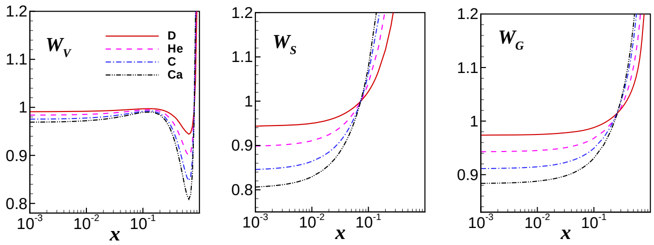


Figure 1: QCD results for weight functions in the NLO for deuteron, helium, carbon and calcium nuclei

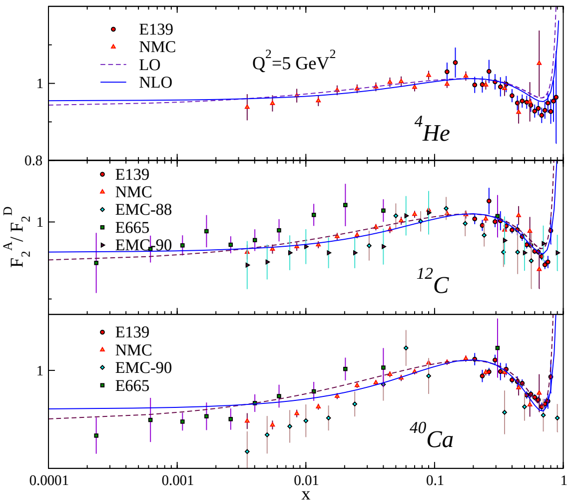


Figure 2: Our QCD results are compared with the experimental data at $Q^2 = 5$ GeV$^2$ for helium, carbon and calcium nuclei in the LO and NLO.

weight functions by a $\chi^2$ analysis of the data on ration of nuclear structure functions [10–15]. In Fig. 1 we plot our QCD results for weight functions in the NLO, which defined in Eqs. (5, 6) for deuteron, helium, carbon and calcium nuclei. In Fig. 2 our results are compared with the experimental data at $Q^2 = 5$ GeV$^2$ for helium, carbon and calcium nuclei in the LO and NLO.


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