Nuclear effects in structure functions for ν-induced reactions

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In the neutrino energy region of a few GeV, lots of theoretical as well as experimental efforts are going on in order to understand the nuclear effects in the neutrino oscillation experiments. Several nuclei like ^{12}C, ^{16}O, ^{40}Ar, ^{56}Fe and ^{208}Pb are being widely used as nuclear targets. ^{56}Fe is being used at MINOS, very soon MINERνA is going to start taking data using ^{56}Fe as one of the target material, recently INO has been sanctioned to do atmospheric neutrino experiment using iron calorimeters. The neutrino nucleus cross section in the deep inelastic region is described in terms of F_2^A and F_3^A nuclear structure functions [1]. For the deep inelastic neutrino-nucleus scattering there are only a few calculations where the dynamical origin of the nuclear medium effect has been studied, and in some theoretical analysis nuclear medium effect has been phenomenologically described in terms of a few parameters which are determined by fitting the experimental data of charged leptons and (anti)neutrino deep inelastic scattering from various nuclear targets. On the experimental side, recently F_2^A and F_3^A nuclear structure functions in iron have been measured at Fermi lab by NuTeV collaboration [2] to improve their earlier results as well as there are experimental measurements available from the CDHSW collaboration [3]. In this work, we have studied nuclear medium effects on F_2^A and F_3^A in a theoretical model using spectral function to describe the momentum distribution of nucleons in the nucleus. The spectral function [4] has been calculated using the Lehmann's representation for the relativistic nucleon propagator and nuclear many body theory [5] is then used to calculate it for an interacting Fermi sea in nuclear matter. A local density approximation is then applied to translate these results to finite nuclei. For the parton distribution functions(PDFs) CTEQ parameterization [6] has been used. The QCD evolution of the structure functions has been incorporated following Ref. [7]. The effect of pion and rho meson contributions, target mass correction, and nuclear shadowing and anti-shadowing effects have also been taken into account following respectively the references [5], [8] and [9]. In the case of pions we have taken the pionic parton distribution functions given by Gluck et al. [10] and for the rho mesons the same PDFs as for the pions.

Our base equation for the nuclear structure functions F_2^A and F_3^A are [1]:

$$F_2^A(x,Q^2) = 4\int d^3r \int \frac{d^3p}{(2\pi)^3}\int_{-\infty}^{\mu} d\omega \times S_h(\omega,\mathbf{p},\rho(\mathbf{r}))\left(\gamma'^2 + \frac{6x'^2(\mathbf{p}^2-p_z^2)}{Q^2}\right)\frac{(1-\gamma\frac{p_z}{M})}{\gamma^2}F_2^N(x',Q^2)$$

$$F_3^A(x,Q^2) = 4\int d^3r \int \frac{d^3p}{(2\pi)^3}\int_{-\infty}^{\mu} d\omega \times S_h(\omega,\mathbf{p},\rho(\mathbf{r}))\frac{p_0\gamma - p_z}{(p_0-p_z\gamma)\gamma}F_3^N(x,Q^2)$$

where $S_h(\omega,\mathbf{p},\rho(\mathbf{r}))$ is the nuclear spectral function, p=$(M+\omega,\mathbf{p})$, $\gamma = (1+4x^2M^2/Q^2)^{\frac{1}{2}}$, $x=\frac{Q^2}{2Mq^0}$, $\gamma'^2 = 1+4x'^2p^2/Q^2$

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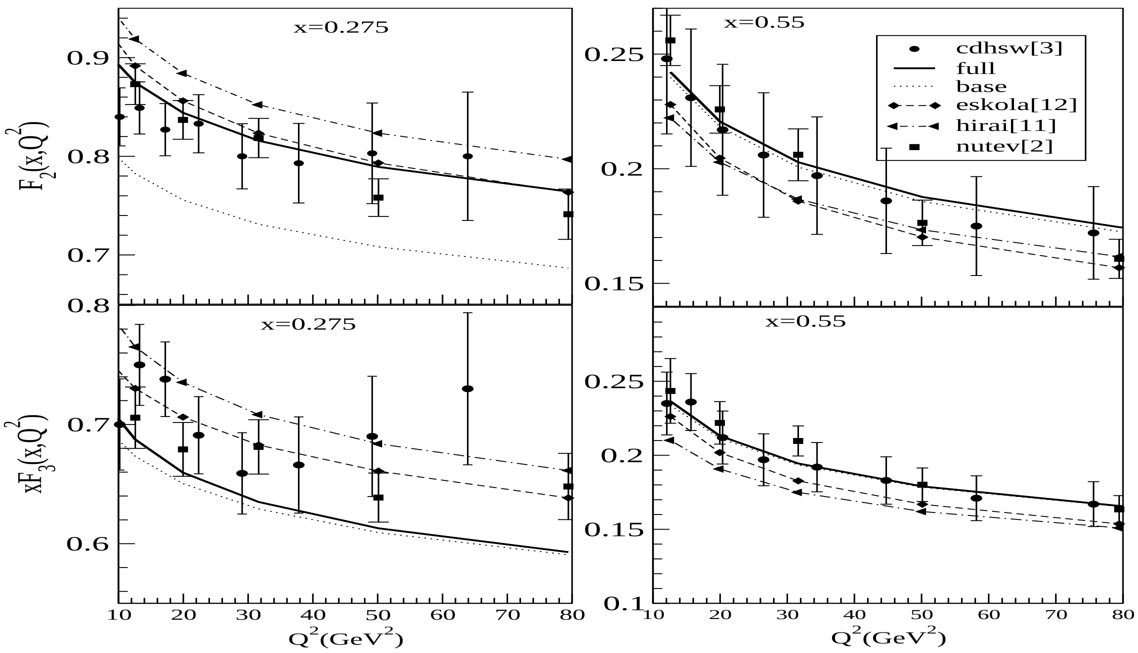

FIG. 1: F_2^A and F_3^A structure functions in Iron.

and $x' = \frac{Q^2}{2p.q}$, F_2^N and F_3^N are free nucleon structure functions.

In Fig.1, we have presented the numerical results for the F_2 and F_3 structure functions as a function of Q^2 at some values of x and compared them with the experimental results of NuTeV and CDHSW collaborations. Furthermore, these numerical results have been compared with the results obtained from some of the phenomenological studies performed by Hirai et al. [11] and Eskola et al. [12]. These results are presented using our base equation and with full calculations where pion and rho meson contributions and nuclear shadowing and anti-shadowing effects are taken into account Our results using the full calculations agree with the recently measured structure funtions by the NuTeV collaboration. The details of the formalism and results would be presented in the symposium.

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