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Evaluation of deep inelastic scattering of nucleon in the gluon structure functions

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Abstract

It is known that between quarks the basic particle acts as the conversation particle for the strong force is gluon and the gluon have two separation states due to gauge invariance. Inside hadron the baryons such as proton and neutrons uses electron, muons and neutrino the process is deep inelastic scattering. Deep is considered to be the high energy of lepton that gives very short wavelength which penetrates a small size target. The goal of this paper is to obtain the following reality evaluation of Deep Inelastic scattering of nucleon in the gluon structure, to observe the agreement between the electron and muon. The method initiate is the cross section. The deep inelastic scattering of nucleon in the gluon structure has been achieved and it has been observed that the electron and muon are in agreement with each other. For electron, muon and neutrino disagree to each other. The bound and pseudo free nucleon within the nucleus do not behave in the same way. Measurement production has been carried out. Small dependent on nuclear dependence has been achieved.

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1.0 Introduction

An elementary particle that acts as the exchange particle or gauge boson for the strong force between quarks is known as a gluon (Abreu, 2000). The exchange of photons in the electromagnetic force between two changed particles through analogous of quarks (Nave, 2012). The formation of hadrons such as protons and neutrons was results of gluons bind quarks together. In technical terms, gluons are vector gauge bosons that mediate strong interactions of quarks in quantum Chromodynamics (QCD) which means that photon has a spin of 1 (Stella and Meyer, 2011). Gluons themselves carry the color charge of the strong interaction of quarks in Quantum Chromodyamics. This is unlike the photon which mediates the electromagnetic interaction but lacks an electric charge. Gluons therefore participate in the strong interaction in addition to mediating it, making Quantum Chromodynamics (QCD) significantly harder to analyze than quantum electrodynamics (QED) (Ali and Kramer, 2011). The massive spin 1particles have three polarization states while the massless gauge bosons like the gluon have only two polarization states due to gauge invariance requires the polarization to be transverse to the constant that the gluon is traveling (Abreu, 2000). In quantum field theory, unbroken gauge invariance requires that gauge bosons have zero mass.

The process used to probe the insides of hadrons (particularly the baryons, such as protons and neutrons), using electrons, muons and neutrinos is known as Deep inelastic scattering. It provided the first convincing evidence of the reality of quarks, which up until that point had been considered by many to be a purely mathematical phenomenon which is a relatively new process, first attempted in the 1960s and 1970s (Friedman, 2008). It is an extension of Rutherford scattering to much higher energies of the

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scattering particle and thus to much finer resolution of the components of the nuclei. The research worrisome deep inelastic scattering of electrons on protons and bound neutrons which have been of necessary conditions for the direct change of the quark model in particle physics (Amsler, 2014). Scattering refers to the lepton's electron, muon deflection which measuring the angles of deflection gives information about the nature of the process and inelastic means that the target absorbs some kinetic energy. Emotions of many new particles are as a result of very high energies of leptons used which particles are hadrons and to oversimplify greatly. The process is interpreted as a constituent quark of the target being knocked out of the target hadron, and due to quark confinement. The quarks are not actually observed but instead produce the observable particles by hadronization (Friedman, 2008). The deep refers to the high energy of the lepton, which gives it a very short wavelength and hence the ability to probe distances that are small compared with the size of the target hadron, so it can probe deep inside the hadron. Also, note that in the perturbative approximation it is a high-energy virtual photon emitted from the lepton and absorbed by the target hadron which transfers energy to one of its constituent quarks. There were three types of particles: the leptons, which were low-mass particles such as electrons, neutrinos and their antiparticles. They have integer electric charge, the gauge bosons, which were particles that exchange forces. These ranged from the massless easy to detect photon the carrier of the electro-magnetic force to the exotic though still massless gluons that carry the strong nuclear force and the quarks, which were massive particles that carried fractional electric charges. They are the building blocks of the hadrons. They are also the only particles to be affected by the strong interaction (Devenish and Cooper, 2013). Rutherford had discovered that atoms had a small massive charged nucleus at their centre by firing alpha particles at atoms of gold (Overbye, 2010). Most had gone through with little or no deviation, but a few were deflected through large angles or came right back which was suggested that atoms had internal structure and a lot of empty space. In order to probe the interiors of baryons, a small, penetrating and easily produced particle needed to be used. Electrons were ideal for the role, as they are abundant and easily accelerated to high energies due to their electric charge (Friedman, 2008). In 1968, at the Stanford Linear Accelerator Center (SLAC), electrons were fired at protons and neutrons in atomic nuclei (Nolan, 2015). The gluon structure study of the nucleon has to be through the deep inelastic scattering which can be explained in terms of the nucleon. However, the electron, muon and neutrino scattering can be explained through the incoherent sum of quasielastic scatters from the quarks.

2.0 Materials and methods

The cross-section in the single photo/boson exchange approximation is then given by Change lepton e or μ scattering

$$\frac{d\sigma}{dxdy} = \frac{4\pi\alpha^2}{Q^4} ME\left[XY^2F_1(X,Q^2) + \left(1 - Y\frac{MXY}{2E}\right)F_2(X,Q^2)\right] \quad 1$$

Neutrino/anti-neutrino scattering

$$\frac{d\sigma}{dxdy} = \frac{G^2ME}{\pi}\left[XY^2F_1(X,Q^2) + \left(1 - Y\frac{MXY}{2E}\right)F_2(X,Q^2) \pm y\left(1-\frac{y}{2}\right)XF_3(X,Q^2)\right] \quad 2$$

Where F_1 and F_2 are the structure functions of the target nucleon (Grinstein, 2012). The target nucleon define the structure as the analogous the electromagnetic form factor G_E and G_M but in general function of two variables x and Q^2 rather than just Q^2. F_3 appears as the third structure function in the neutrino cross-section due to the non-conservation of parity in the weak interaction. F_1 and F_2 are related through the expression

$$R(X,Q^2) = \frac{F_2(X,Q^2)\left(1+\frac{Q^2}{y^2}\right) - 2xF_1(X,Q^2)}{2xF_1(x,Q^2)} \quad 3$$

Thus the unknown parameters of the interaction are defined in terms of the structure function F_1, F_2, F_3 or R, F_2, F_3 (Amine *et al.*, 2015). In the Quark model of the nucleon F_2 is at large Q^2 and is given by the incoherent sum of scattering from the constituents of the nucleon. Thus for μ-nucleon scattering

$$F_2 = \sum_f e_f^2\, xq_f(x) \quad 4$$

Where $q_f(x)$ is the momentum distribution function of the f^{th} quark

e_f is the charge of the f^{th} quark

Also the constituent quarks have spin$\frac{1}{2}$ so that

$$2xF_1(x) \sim F_2(x) \quad 5$$

And

$$R(x) \sim 0 \quad 6$$

Or more generally, for quarks of mass M_q and transverse momentum P_T

$$R(x) = \frac{4\,(P_T^2 + M_q^2)}{Q^2} \quad 7$$

Low Q^2 *and the neutrino and muon electron* F_2's are related by

$F_2^{\mu N} = \frac{5}{18} F_2^{VN}$ 8

3.0 Results and discussion

The structure functions can be determined from combination of the measured charged and neutral lepton cross section

$\sigma^{VN} \rightarrow F_2^{\mu N}$ 9

$\sigma^{VN} + \sigma^{\bar{V}N} \rightarrow F_2^{VN}$ 10

$\sigma^{VN} + \sigma^{\bar{V}N} \rightarrow F_2^{VN}$ 11

$E \rightarrow R$ 12

$\sigma^{VN} - (1-y)^2 \sigma^{VN} \lim_{y \to 1} \rightarrow \bar{q}$ 13

The quantities of σ at fixed x, Q^2 values but using different beam energies equation 13 is the antiquark or sea quark distribution function. Apart from motion effects, the nucleus structure function can be simplify by $\frac{1}{A}$ multiplied by the sum of its constituent nucleon structure functions, i.e for iron

$F_2^{Fe}(x) = \frac{1}{56}\left[26\, F_2^p(x) + 30 F_2^n(x)\right]$ 14

Where F_2^p and F_2^n are the free proton and nucleon structure function respectively.

The variation can be equally well described in terms of a logarithmic decrease in the ratio with increasing A

$\frac{\sigma(A)}{\sigma(D)_2} = CA^{\alpha(x)}$ 15

Or linearly with the average nuclear density

$\frac{\sigma(A)}{\sigma(D)_2} = a\big(1 + b(x)\rho(A)\big)$ 16

Where a and b are x-dependent fit parameter.

$\frac{\int \bar{q}(Ne)dx}{\int \bar{q}(H_2)dx} = 0.95 \pm 0.16 \sim 1GeV^2$ 17

or

$\frac{\int \bar{q}(Ne)dx}{\int \bar{q}(D_2)dx} = 0.91 \pm 0.06 \sim 1GeV^2$ 18a

$\frac{\int \bar{q}(Ne)dx}{\int \bar{q}(D_2)dx} = 0.85 \pm 0.10 \sim 8GeV^2\ (Q^2 \geq 4.5)$ 18b

$\frac{\int \bar{q}(Ne)dx}{\int \bar{q}(H_2)dx} = 1.10 \pm 0.11 \pm 0.07 \sim 7GeV^2$ 19

To analysis the energy momentum sum which can be shown that 50% of the momentum of the nucleon is carried by its constituent quarks.

$\int F_2^{VN}(x)\, dx = 0.51$ 20

$\int F_2^{\mu N}(x)\, dx = 0.14$ 21

Inside the nucleon the other 50% is carried by gluon which couple to the quarks and confine them. The $G(x)$ within the framework of Quantum Chromodynamics the Q^2 evolution can explain the momentum distribution and structure functions R, F_2 *and* xF_3 can be predicted with great success.

The normalization is

$\int F_2(x) + G(x)\, dx = 1$ 22

x-dependence is seen and the results when combined give

$\frac{G(x)^{Fe}}{G(x)^{D_2}} = 1.44 \pm 0.12 \pm 0.20$ 23

Equation 23 shows that the gluon distribution in iron of the region is systematically larger than that for deuterium.

$R = \frac{\sigma_L}{\sigma_T}$ 24

Equation 24 is the structure function R which can be used to determine the any nuclear dependence.

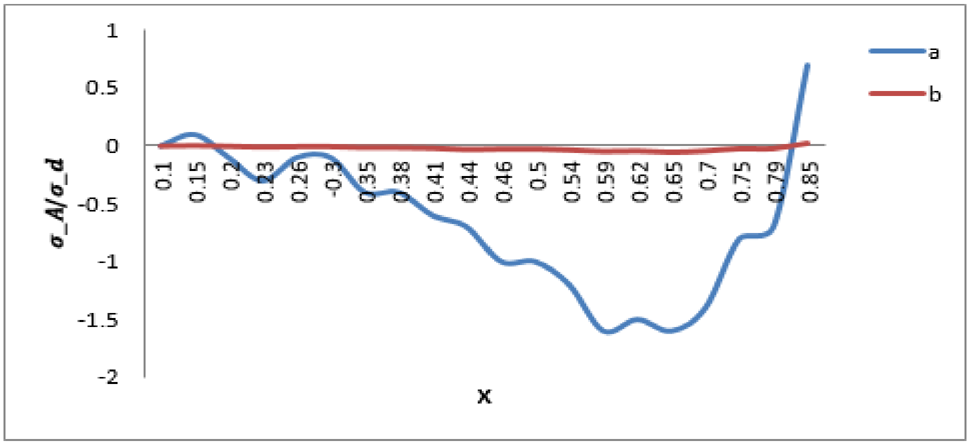

Figure 1: X against $\frac{\sigma_A}{\sigma_d}$ for fit parameters

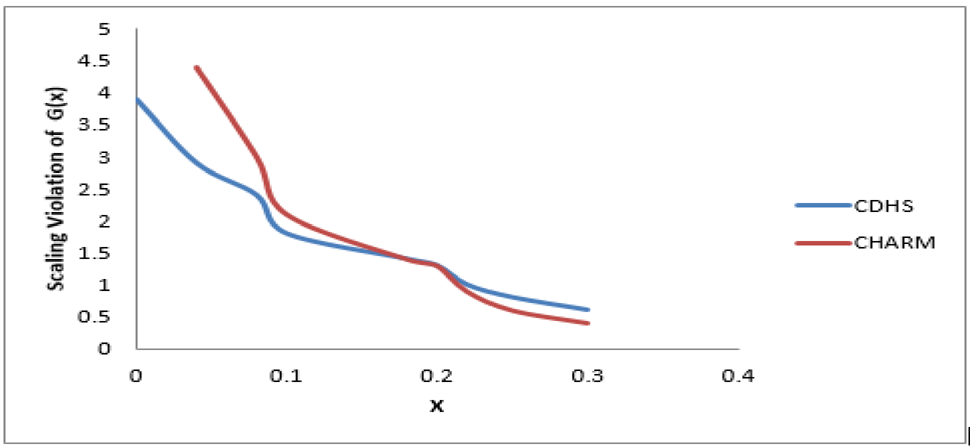

Figure 2: X against Scaling Violation of Gluon Structure Function (G(x))

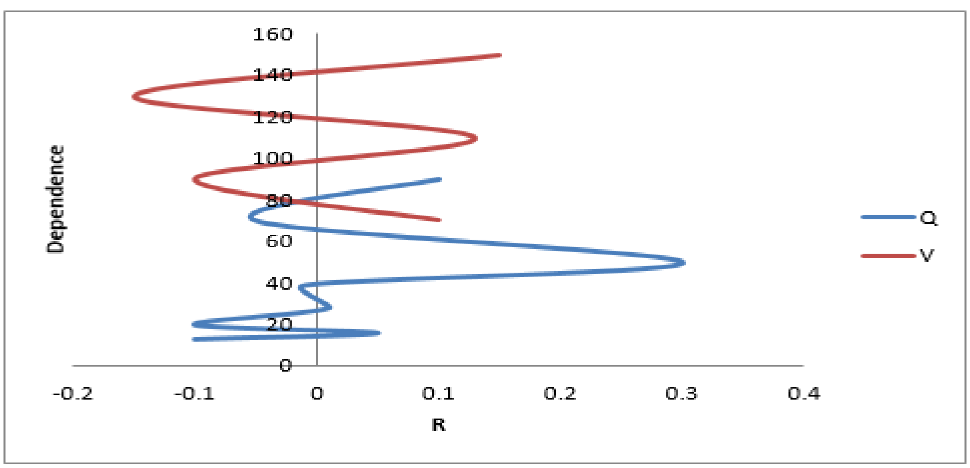

Figure 3: R against Dependence at large Q^2

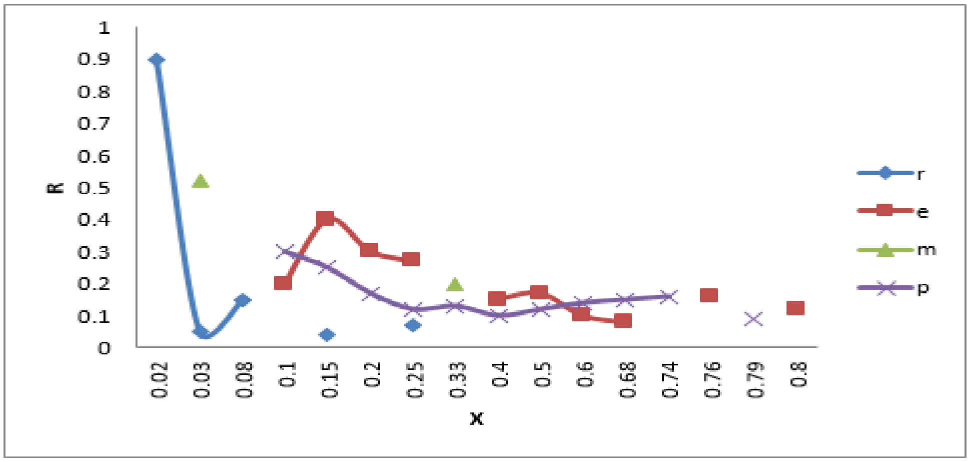

Figure 4: X-dependence against R of small Q^2

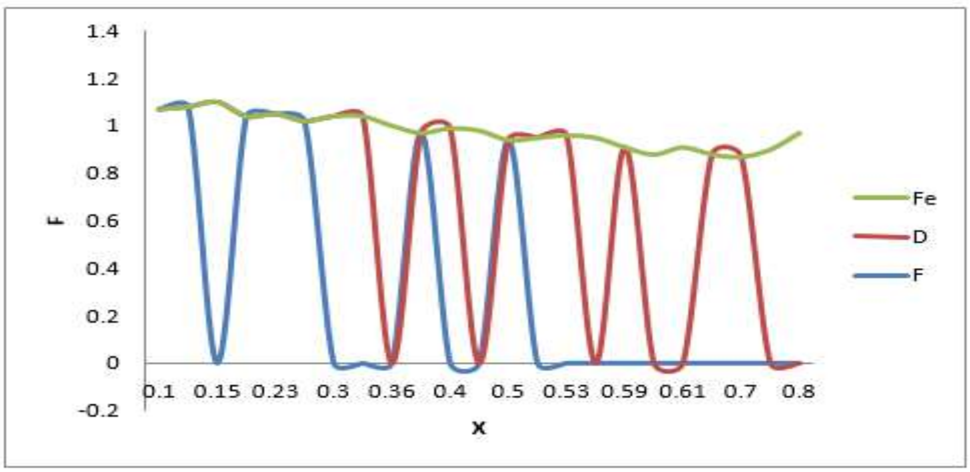

Figure 5: X against F for ratios Results of $\frac{F_2(F_e)}{F_2(D_2)}$

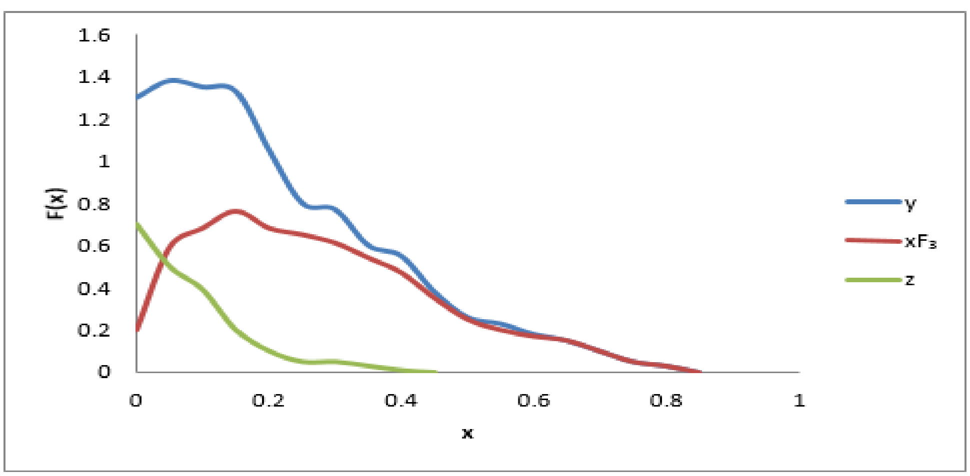

Figure 6: X against F(x) for Q^2 region $10 < Q^2 < 30\ GeV^2$

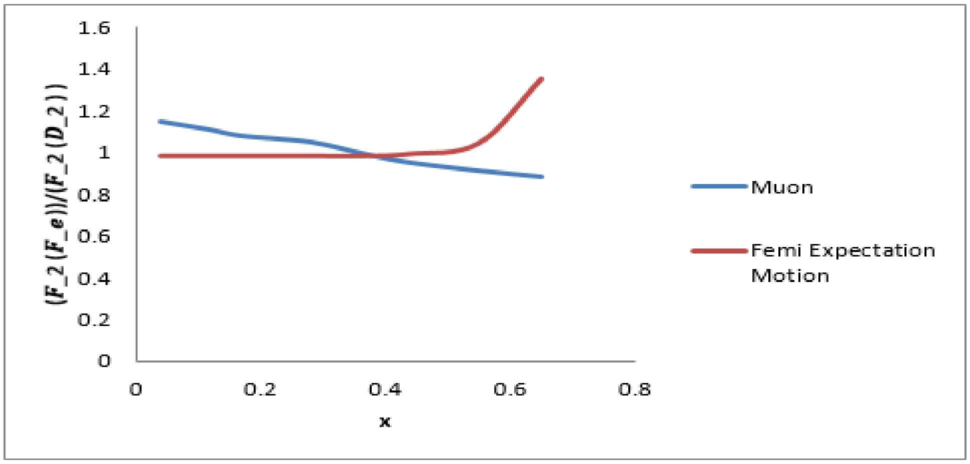

Figure 7: X against ratio $\frac{F_2(F_e)}{F_2(D_2)}$ without Fermi motion

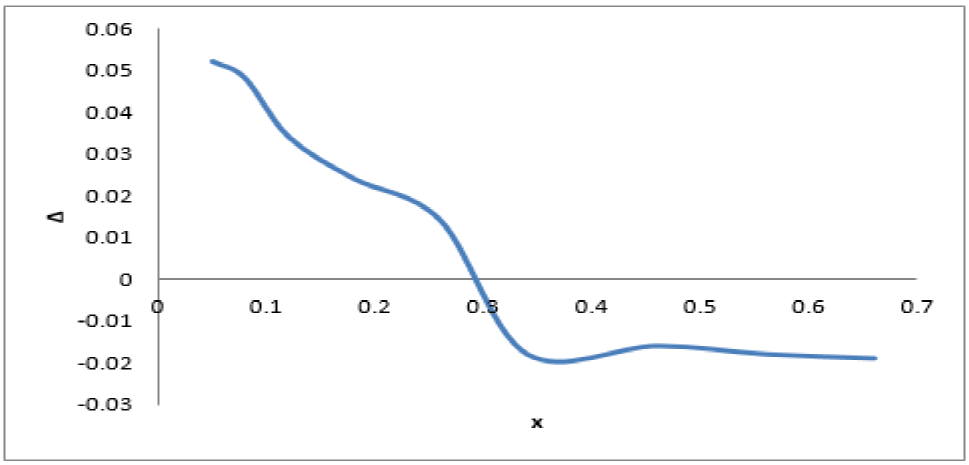

Figure 8: X against Δ for an increase in $\bar{q}$

The Figure 1 shows the comparison with the W^{139} which production have presented results from N_2 in the kinematic region $0.25 \leq x \leq 0.65$ and $40 \leq Q^2 \leq 190\ GeV^2$. Also measurement has carried out for the production on Be, C, Al, Ca, Fe, Ag and Au target in the kinematic region $0.09 \leq x \leq 0.9$ and $2 \leq Q^2 \leq 15\ GeV^2$. Similar x-dependences for each material that the results consistent with one for $0.1 \leq x \leq 0.3$ and then falling below one in the manner above for $0.3 \leq x \leq 0.8$.

Figure 2 indicates that the best to finding of G(x) to come from Fe and $CaCO_3$ productions. Also there is reasonable agreement inside the large uncertainties on the measurement. The only slight difference is that $CaCO_3$ distribution is slightly softer than that of Fe. An alternative approach to try to compare G(x) for iron for deuterium and adopted has been measure $\frac{J}{\Psi}$ production cross-sections of the two target which compare the results.

Figure 3 indicates that proton or Q is a typical of the measurements in this division in that it proves little or no visible dependence on v, Q within errors. This shows it is more accessible to integrate over all variables and produce a $Q - x$ or $Q - v$ averaged results. One can conclude that in addition to a lack of any mechanics dependence that R is closed to zero that is any nuclear dependence at large Q must be small. The lower Q measurement one finds that the small but non-zero values are found for R and that there some indications of an x-dependence.

Figure 4 indicates that a small dependent target difference which it interpret these as evidence for a possible nuclear dependence of R. It shows that one must be careful here as with the evaluation of the electron-proton and electron-deutron that come from various cover $x - Q$ regions. As with the large Q result indicated that the average R values from these one can argue that at least some of the stated effect may be due to a Q- dependence.

Figure 5 proves that $x \geq 0.3$ is essentially in charged also for the measure R difference of 0.15 ± 0.11. It indicate that no low x rise in the ratio which makes it interesting to see a rise which is entirely consistent with the high Q^2.

Figure 6 indicates that the results are in common agreement in both x and Q^2 and the absolute normalization agrees within 5% to 7% between. In Quantum Parton Model is shown to work very well that only small Q^2 dependence is detected that can be impute in limitations of Quantum Chromodynamic (QCD) radioactive substitution. It also shows that a result that build for Q^2 region $10 < Q^2 < 30\ GeV^2$ plotted graph as a function of x. The Quark Parton Model $\frac{5}{18}$ factors that the shape of sea quark distribution which falls speeds with x and stop out by $x{\sim}0.3\ to\ 0.4$. From the Figure, y is represent as F_2 and also z is shown as $\bar{q}^{v}$.

Figure 7 proves the observation of Muon the ratio of the structure function F_2^{VN} size on iron when compared to that sized on deuterium perverted from the considered ratio of one by up 15% and indicated major x-dependence. Also it proves that have been averaged conclude the avail Q^2 range for each value of x. The statistical difference are indicate that the effect cannot unfold away and the basis of systematic uncertainties as these are $> 7\%$. It implies that even at large Q^2 the nucleus do not conduct as an incongruous deposition of free nucleons. Fermi expectation motion of the nucleus inside the nucleus also do not review for the effect as the corrected for the deuterium is smaller than iron.

Figure 8 indicated that the low x improvement of the ratio $\frac{F_2(F_e)}{F_2(D_2)}$ and the different $\Delta = F_2(F_e) - F_2(D_2)$ are in muon result, possibly due to a substantial rise in the sea quark distribution in the iron nucleon. Also the ensue from functions based on the x-dependence of Δ that proves a great size improvement in the small x sea quark region and only a small resource in the great size x valence quark region. Neutrino have a direct access to the neutrino $\bar{q}$ distribution through the y-dependence of the neutrino cross section.

4.0 Conclusion

On structure functions can be conclude that muon effect has now been established and pseudo free nucleons inside the nucleus do not behave in the same way. There is an agreement between Fe and $CaCO_3$. The comparisons of the gluon distribution in iron and deuterium which the glue in iron could be enhanced in the deuterium in the small x region.

Declarations

Ethics approval and consent to participate

Not Applicable

Consent for publication

All authors have read and consented to the submission of the manuscript.

Availability of data and material

Not Applicable.

Competing interests

All authors declare no competing interests.

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