Chapter 10

Conclusion

This thesis concerns with the determination of both the spin independent and spin dependent non-singlet structure functions and sum rules associated with them. We have employed a unified approach incorporating Regge theory and the theoretical framework of perturbative Quantum Chromodynamics. Incorporating two Regge ansatz, one with constant intercept and Q^2 dependent coefficient and the other one with Q^2 dependent intercept and constant coefficient as the initial input, we have solved the Dokshitzer-Gribov-Lipatov-Altarelli-Parisi (DGLAP) evolution equation for the non-singlet structure functions $F_2^{NS}(x, Q^2)$, $xF_3(x, Q^2)$ and $xg_1^{NS}(x, Q^2)$. Here we explicitly specify how the usefulness of two Q^2 dependent Regge ansatz, utilized as the required initial input to the DGLAP evolution helps in obtaining the small-x behaviour of the non-singlet structure functions. Obtained small-x behaviour of these non-singlet structure functions are then utilized to calculate the sum rules – Gottfried sum rule(GSR), Gross-Llewellyn Smith sum rule(GLSSR) and Bjorken sum rule (BSR), which are associated with $F_2^{NS}(x, Q^2)$, $xF_3(x, Q^2)$ and $xg_1^{NS}(x, Q^2)$ respectively. In addition to the prediction of structure functions and sum rules we have paid attention to their precision. Precise prediction of structure functions demand to incorporate the standard higher order approximation of pQCD and several non-perturbative effects. In this regard particular emphasis is given to the determination of structure functions and sum rules with pQCD corrections up to next-next-to-leading order (NNLO) and to the inclusion of the special non-perturbative effects, the nuclear effect and higher twist effect.

The non-singlet structure functions evolved in accord with the DGLAP evolution equations are studied phenomenologically and the analysis is presented in the chapters 4, 5 and 6 for $F_2^{NS}(x, Q^2)$, $xF_3(x, Q^2)$ and $xg_1^{NS}(x, Q^2)$ respectively in comparison with several experimental as well as parametrization results. We observe a very good consistency between our calculation and other experimental as well as parametrization results within the kinematical region $x < 0.05$ and $Q^2 = 20GeV^2$ of our consideration, especially, if the NNLO results are concerned. The phenomenological success achieved in this study suggests that the two simple QCD featured Regge behaved ansatz are capable of evolving non-singlet structure functions in accord with DGLAP equations at small-x. However from the comparative picture between the most consistent results, the NNLO results for both the inputs along with other experimental and parametrization results we do not observe any significant differences among them within our region of consideration. We hope future experimental measurements at extremely small values of Bjorken x will clarify their differences and help us in better understanding of the structure of nucleon.

As the small-x behaviour of the non-singlet structure functions $F_2^{NS}(x, Q^2)$, $xF_3(x, Q^2)$ and $xg_1^{NS}(x, Q^2)$ are well explicable through our analytic expressions obtained by means of solving DGLAP evolution equations, we have employed them in the determination of the corresponding sum rules GSR, GLSSR and BSR through a simple but efficient technique, discussed in chapter 7. As we do not observe any significant differences among the results of the two ansatz, therefore in the determination of sum rules we have utilised the results of the ansatz with Q^2 dependent intercept only. The phenomenological analysis of our results in comparison with other experimental, theoretical as well as phenomenological results suggest that our calculations are compatible with other strong measurements.

We also consider the contribution of nuclear shadowing effect to the non-singlet structure functions and sum rules. Incorporating the corrections due to shadowing nuclear effect, proposed in different theoretical as well as phenomenological analysis to our results of the structure functions and sum rules for free nucleon, we obtain nuclear structure functions and sum rules and perform phenomenological analysis in comparison with available data and parametrization. The nuclear structure functions thus obtained are observed to be consistent with other experimental measurements.

Further we have extracted the higher twist effects in the non-singlet structure functions and sum rules based on a simple model, which is discussed in chapter 9. The phenomenological analysis of our results for structure functions and sum rules, along with considerable higher twist correction provide a very good description of their respective experimental data and parameterizations.

From the phenomenological analysis discussed above we have the following observations:

i. The Regge inspired ansatz in accord with DGLAP equations provides a very good description of the small-x behaviour of non-singlet structure functions, which are consistent with other results taken from different experiments and parameterizations.

ii. Inclusion of nuclear effect and higher twist corrections lead to a better description of the experimental results for various non-singlet structure functions.

iii. Our results for the sum rules associated with the non-singlet structure functions are observed to be compatible with their respective available data as well as parameterizations.

iv. Our expressions for GLS sum rule and Bjorken sum rule, along with considerable higher twist correction provide a very good description of the experimental measurements which indicates that the experimental data strongly confirm the QCD predictions for different sum rules.

v. Our results for Q^2 behaviour of different sum rules are also consistent with the QCD predictions up to NNLO. This consistency between our results and theoretical QCD predictions suggests that available data, the Regge ansatz and the theoretical framework of pQCD, through this simple method allow us to have a clean test of pQCD predictions on the respective sum rules.

vi. The consistency of the results for the non-singlet structure functions and sum rules due to the Regge like model, $xg_1^{NS}(x,t) = Ax^{1-bt}$ with different experimental results and other strong analysis signifies that the model is applicable in describing the small-x behaviour of structure function although it being simple. Moreover, in this method we do not require the knowledge of initial distributions of structure functions at all values of x from 0 to 1. Here, we just require one input point at any fixed x and Q^2 and with respect to that point both the x and Q^2 evolution of structure functions can be obtained.

Our concluding impression based on all these observations is that the simple but efficient Q^2 dependent Regge ansatz for non-singlet structure functions is capable of evolving successfully the structure functions in accord with DGLAP equation at small-x and the Regge ansatz and the theoretical framework of pQCD, along with available experimental data lead towards a clean test of pQCD predictions of Sum Rules. □□