Plan Of Work

I wish to pursue the following investigations during my stay at Fermi Lab:

1. Modelling for the Deep Inelastic Sacttering(DIS) region

   In the energy region of MINERνA experiment (upto a few GeV), nuclear medium effects are quite important. We have performed the calculations of nuclear medium effects in DIS region which can be applied in the region of x and Q^2 relevant for this experiment. We have shown that our model can explain x as well as Q^2 dependence in $F_1^{EM}(x,Q^2)$, $F_2^{EM}(x,Q^2)$ for the recent measurements performed using several nuclear targets at JLab. This has important implications in the analysis of MinerνA experiment which we proposed to study for the weak structure functions viz. $F_1^{Weak}(x,Q^2)$, $F_2^{Weak}(x,Q^2)$ and $F_3^{Weak}(x,Q^2)$.

   Interaction with the members of the MINERνA collaboration working at Fermi Lab will benefit my understanding and perception of neutrino physics in the DIS region.

2. Modelling for Shallow Inelastic region(SIS)

   In the energy region of $E_{\nu,\bar{\nu}} \sim 1.5 - 3GeV$, there are several resonances which contribute, while the deep inelastic reaction dominates in the high energy region($E_{\nu,\bar{\nu}} > 3GeV$). It is very difficult to theoretically describe the neutrino nucleus cross section in the energy region lying between the resonance region and the deep inelastic region. Recently with the emphasis on the precision neutrino physics, lots of theoretical and phenomenological works have been performed to understand the resonance region and the DIS region. The importance of understanding the neutrino nucleus cross section in the transition region has been emphasized. This is because the energy in this region is high enough to excite many resonances which are not well described by the effective Lagrangian approach, while the energy is not high enough to apply the methods of perturbative QCD. A description of $\bar{\nu}(\nu)-$nucleus cross sections in this region therefore is quite important. In EM sector, the duality has been observed in inclusive electron scattering from nucleons and nuclei. The local and global dualities seem to work in the individual resonance region as well as in the entire resonance region taken together [1]-[2].

   In the case of electron nucleus scattering also the data from JLab on electron scattering from some nuclei have been phenomenologically analyzed and quark-hadron duality seems to work well. Theoretically, it will be useful to analyze the nuclear medium effects in resonance production as well as in the DIS region and to examine the validity of quark-hadron duality

in electron scattering from ^{56}Fe and other nuclear targets like ^{12}C, ^{27}Al, ^{63}Cu, ^{208}Pb in which data from JLab [3] will be available in future.

In the weak sector, the quark hadron duality has been shown to work in neutral current(NC) sector of polarized electron nucleon scattering as observed in the parity violation(PV) asymmetry of electron from proton and deuteron [4]. There has been no study of quark-hadron duality in CC and NC sector of neutrino and antineutrino interactions. This is mainly due to lack of (anti)neutrino scattering data on the resonance production from nucleons and nuclei. However, there are some theoretical studies to test quark hadron duality where $\bar{F}_i^R(Q^2)$ and $\bar{F}_i^{DIS}(Q^2)$ have been calculated in certain theoretical models [5–10]. Now that some data are available on Δ production from SciBooNE, MiniBooNE, MINERvA and T2K experiments and DIS data from CCFR, BCDMS, NuTeV and MINERvA experiments, it will be very useful to test local quark-hadron duality in nuclei in the (anti)neutrino scattering particularly in the Δ resonance region. If theoretical calculations validate, the quark hadron duality will also provide a useful alternative method to model the (anti)neutrino-nucleus cross sections in the entire (anti)neutrino energy region including the transition region. This is highly desirable as this will provide a method to calculate (anti)neutrino nucleus cross sections in the entire region of $\nu(\bar{\nu})$ energies relevant for ν-oscillations experiments [11, 13, 14].

3. Interacting with the group performing DIS and SIS analysis for MINERνA, specially doing the theoretically calculation in the MINERνA kinematical range and discussing problems of present interest.

4. Experimental analysis at MINERνA

   Currently MINERνA is taking data in medium energy region. I am also involved in the (anti)neutrino-nucleus analysis in the DIS region. Being a theorist to involve in the experimental analysis may help the experimentalist to understand theoretical view of the neutrino interactions. I find it very useful and I feel that the people involved in the experiment also feel good while interacting with a theorist. My stay at the Fermilab will also be beneficial for me as well as the working group at MINERvA if I continue doing the analysis.

5. Plan to tune GENIE MonteCarlo for the DIS and SIS region with Gabriel Nathan Perdue(Fermilab) and Hugh Gallagher(Professor at Tufts University) the MINERνA collaborators. In this region very few theoretical efforts have been made and to understand this region our collective efforts are needed.

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