Contribution ID: **81** Type: **not specified**

Importance of study of quasielastic hyperon production at DUNE energies

Wednesday, March 17, 2021 8:55 AM (10 minutes)

In the era of precision measurement, the main aim is to determine the neutrino oscillation parameters with better precision and to search for the CP violation in the leptonic sector, for which the simultaneous knowledge of neutrino and antineutrino cross section in the same energy region, for a given nuclear target is required. In the few GeV energy region of neutrinos and antineutrinos, the contribution to the total scattering cross section comes from the quasielastic, inelastic, and deep inelastic scattering processes. In the case of antineutrinos, apart from the aforementioned processes, the single hyperon production, although being Cabibbo suppressed, also contributes to the total scattering cross section in some kinematic regimes. The produced hyperons then decay into a nucleon-pion system thus giving an additional contribution to the single pion production, especially in the low energy region which receives a dominant contribution from the Δ excitation. We have estimated that in the low energy region of $\sim$ 0.3 to 0.6 GeV, the hyperon production competes with the Δ production cross sections [1].

The study of single hyperon production is important in its own right as it provides information about the nucleon-hyperon transition form factors at high Q^2, which are presently known only at low Q^2 from the study of the semileptonic decays of hyperons, where the symmetries of the weak hadronic current like the T-invariance, G-invariance, and SU(3) symmetry are also tested. We have studied the dependence of different vector and axial vector currents including the second class current form factors on the total and differential cross section as well as the time reversal and G-parity violations in the antineutrino induced single hyperon production [2]. We plan to extend our study of the single hyperon production by taking into account the effect of SU(3) symmetry violating form factors used in the various analyses of the semileptonic hyperon decays. Recently, Thorpe et al. [3] have also studied the effect of second class currents, axial dipole mass, and SU(3) symmetry violation on the total and differential scattering cross sections in the antineutrino induced single hyperon production.

Theoretically, we have also studied the polarization components of the hyperons produced in the antineutrino reactions, and the dependence of the form factors on these polarization observables is studied. The longitudinal and perpendicular components of polarization lie in the plane while the transverse component of polarization lies perpendicular to the reaction plane and is forbidden by G- and T-invariance. The experimental measurement of the non-zero value of the transverse component of the polarized hyperon will directly show the violation of time reversal in the weak sector. Fortunately, such kind of studies can be performed at the DUNE experiment at Fermilab, which will use the liquid argon time projection chamber type of detector, and is itself a target and a detector and gives the 3-dimensional track of the interaction. Keeping the above considerations in mind, it is possible in the DUNE experiment to study the physics of T-violation in the leptonic sector by measuring the polarization components of the hyperons and leptons produced in the antineutrino reactions [4]. By studying the polarization components of the polarized hyperon, we may also study the effect of SU(3) symmetry violation in the strangeness sector.

We will present the results to show the effect of the second class current form factor and SU(3) symmetry breaking on the total and differential scattering cross sections as well as on the polarization components of the hyperon and leptons produced in the antineutrino scattering from free nucleons as well as from the Argon nuclear target at DUNE energies.

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Session Classification: Flash Talks