PROCEEDINGS OF SCIENCE

Modeling neutrino-nucleus interactions in the quasi-elastic regime

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In the energy region below 1 GeV, neutrino-scattering off nuclei is dominated by quasi-elastic processes. Several effects influence the outcome of these reactions, and the result of cross section calculations depends on choices in model and parameterization. We discuss the main sensitivities of quasi-elastic processes and their influence on cross section results.

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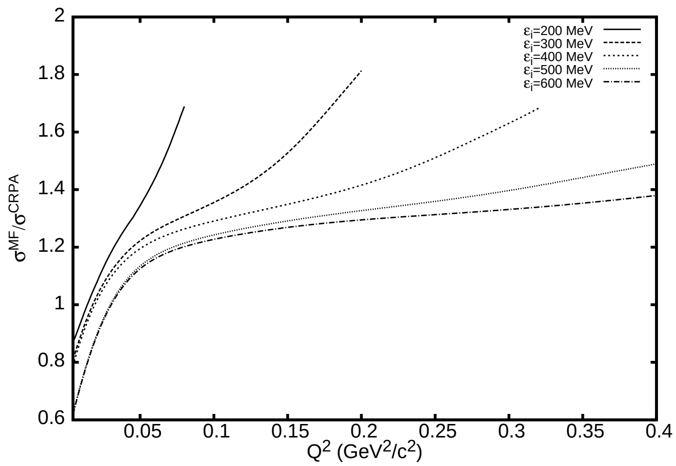

Figure 1: Ratio of cross sections obtained with mean field (MF) wave functions to cross sections including continuum RPA correlations (CRPA) as a function of Q^2 for incoming neutrino-energies ranging from 200 to 600 MeV and with ^{12}C as target nucleus.

In view of the tremendous interest in neutrino interactions, with several operating and planned experiments, a thorough understanding of all the aspects of neutrino-nucleus scattering reactions is indispensable. In this contribution we give a brief overview of the main effects influencing quasi-elastic neutrino-nucleus scattering reactions.

Final state interactions strongly influence the outgoing nucleon in a quasi-elastic reaction. Depending on the energy of probe and ejectile, only about half of the hit nucleons leave the nucleus undisturbed. The others are rescattered into inelastic channels or absorbed [1].

For inclusive cross sections, especially at higher energies, the Fermi gas model is remarkably accurate. At lower energies however, nuclear effects become preponderant and their influence cannot be neglected. As is shown in Fig. 1, long-range Random Phase Approximation (RPA) correlations account for a considerable reduction of cross sections at low incoming neutrino-energy [2].

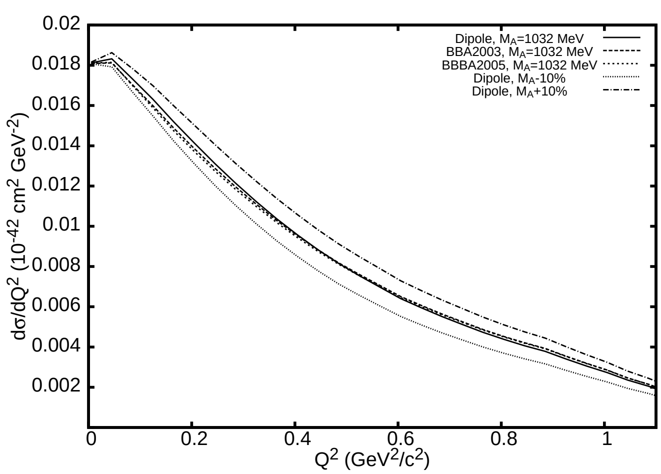

Figure 2: Influence of the Q^2 dependence of the form factors and the value of M_A on relativistic plane wave impulse approximation (RPWIA) cross sections for charged-current neutrino scattering off ^{12}C for an incoming neutrino-energy of 1 GeV.

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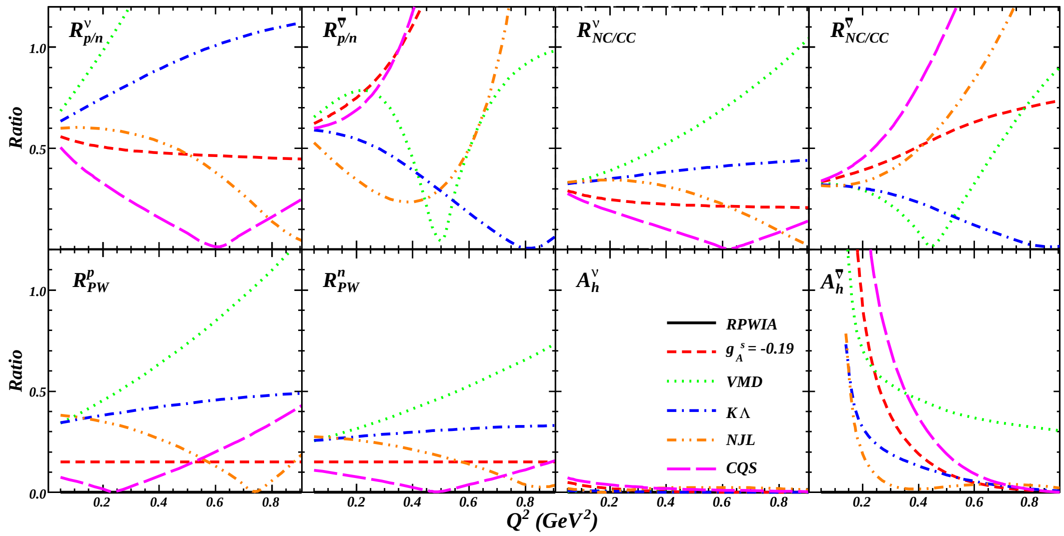

Figure 3: Comparison between the strangeness influence on cross-section ratios in terms of their relative strangeness sensitivity $|\frac{R(s=0)-R(s)}{R(s=0)}|$, for $g_{A_s} = -0.19$, combined with the vector strangeness form factors provided by different hadron models [4]. The different panels show the strangeness sensitivity of the ratio of cross sections for proton-to-neutron knockout, the ratio of neutral-to-charged current cross sections, the Paschos-Wolfenstein ratio, and the longitudinal helicity asymmetry. The incoming neutrino energy is 1 GeV, the target nucleus is ^{12}C.

Fig. 2 illustrates that cross sections are relatively sensitive to the value of the axial mass M_A. The adopted parameterization for the Q^2 dependence of the nucleon form factors only modestly affects the cross sections [3].

Whereas the influence of the strangeness content of the nucleon on neutral current cross sections is rather small, Fig. 3 shows that its influence on cross-section ratios can be huge. Vector strangeness effects are large, and heavily Q^2 dependent. Antineutrino ratios exhibit a more outspoken strangeness sensitivity than their neutrino counterparts. Especially the longitudinal helicity asymmetry for antineutrinos $A_h^{\overline{\nu}}$ depends strongly on vector strangeness contributions. The overall sensitivity of the ratio of neutral-current to charged-current cross sections $R_{NC/CC}$ to strangeness effects is considerably smaller than that for the ratio of cross sections for neutrino-induced proton-to-neutron knockout reactions $R_{p/n}$. At small Q^2, the strangeness influence on $R_{NC/CC}$ is more strongly dominated by the axial channels [4].

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