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Baryon resonance physics and its application to neutrino interactions

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Recent breakthrough measurements of non-zero neutrino mixing angle θ_{13} indicated a possibility of the CP violation in the lepton sector. Now the main concern of the neutrino physics is the leptonic CP violation and mass hierarchy. For making a progress towards this direction by analyzing data from the next-generation long-baseline and atmospheric experiments, neutrino-nucleon and neutrino-nucleus scattering in a wide kinematical region need to be understood much better than what are available at present. Our effort of developing a dynamical coupled-channels (DCC) model for neutrino-nucleon interaction is for challenging this demanding problem. The DCC model is designed to work in the resonance region where single- and double-pion productions are dominant processes. The DCC model is based on meson-exchange non-resonant mechanisms, and excitations of nucleon resonances. The DCC model includes channels relevant to the resonance region of $W \leq 2$ GeV (W: total hadronic energy); they are $\pi N, \pi\pi N, \pi\Delta, \rho N, \sigma N, \eta N, K\Sigma$ and $K\Lambda$. By solving a scattering equation, we obtain unitary amplitudes for meson productions. The DCC model has been developed for the purpose of extracting baryon resonance properties. We have successfully done a DCC-based analysis of world data of $\pi N, \gamma N \to \pi N, \eta N, K\Sigma$ and $K\Lambda$, and extracted properties of the baryon resonances [1]. The DCC model has thus been well tested by a large amount of data. We extend the DCC model to describe the neutrino processes. Non-resonant axial currents are derived from a chiral Lagrangian, while resonant axial currents are fixed by the PCAC relation to the pion couplings. We present results of our calculations for the neutrino-induced meson production cross sections. We discuss roles played by various mechanisms such as Δ-, higher resonance-excitations, and non-resonant mechanisms.

[1] H. Kamano, S.X. Nakamura, T. -S. H. Lee, and T. Sato, Phys. Rev. C **88**, 035209 (2013).