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Tau polarization in (anti-)neutrino-nucleon interactions.

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Detection and identification of tau-neutrino events is of primary interest for the neutrino-oscillation program. While accelerator experiments like DONUT and OPERA reported events with tau-leptons, atmospheric neutrino studies at Super-Kamiokande and IceCube established the $\nu_\mu \to \nu_\tau$ oscillation. Future experiments such as DUNE, DsTau and SHiP are also planning to detect tau-leptons.

The tau-neutrinos are primarily revealed via their charged-current interactions, ${}^{(-)}\nu_\tau\, N \to \tau^{\pm} X$. The short lifetime and heavy mass of tau's make them challenging to identify. However, due to the parity-violating decay modes, the spin information is preserved in tau decay product's kinematics. Therefore, the polarization information plays a vital role in tau-detection.

In this work, we study the semi-inclusive ν_τ-nucleon cross-section and the polarization of produced tau-leptons in a broad kinematic range encompassing quasi-elastic scattering (QE), inelastic scattering(IS), and deep inelastic scattering (DIS) processes. We improve the previous study of Hagiwara et al.(Nucl. Phys. B668 (2003) 364) in the inelastic and deep inelastic regimes. In the IS channel, which is dominated by the excitation of baryon resonances, we rely on the Dynamical Couple Channel model to provide an accurate description of the process in a broader range of hadronic invariant masses, extending to 2 GeV. On the other hand, in the DIS region, we improve the kinematic treatment (especially for low Q^2) and write the structure functions in a more consistent way.

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