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Study of Solar CNO Neutrinos in a Model Water-Based Liquid Scintillator Detector

The “solar metallicity problem” has persisted in solar structure modeling for over three decades. A precise measurement of CNO neutrinos could offer definitive evidence to resolve this issue, as their flux directly reflects the abundance of heavy elements in the solar core. The recent detection of CNO neutrinos by the Borexino experiment using a liquid scintillator detector marked a significant milestone in this field. In this study, we refine solar CNO neutrino flux predictions by incorporating updated nuclear reaction rates, opacities, and metallicity into solar evolution models computed using MESA (Modules for Experiments in Stellar Astrophysics). We then assess the feasibility of detecting these neutrinos, including their directional information, in a model hybrid neutrino detector, specifically a water-based liquid scintillator (WbLS) detector equipped with ultrafast photodetectors. For an idealized 50-kiloton WbLS detector, we predict ˜10ˆ5 solar CNO neutrino events in each year under a low-metallicity solar model. This number increases by a factor of ˜1.5 under a high-metallicity solar model. Background noises are expected to be substantially larger, estimated to be ˜10ˆ8 events per year. However, by leveraging directional information, we anticipate that quantifying solar CNO neutrino events and potentially distinguishing different solar metallicity models would be feasible with several years of data collection.

Collaboration(s)

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