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Probing Neutrino Mass Hierarchy by the Charged-Current and Neutral-Current Events of Supernova Neutrinos in Scintillation Detectors

The neutrino mass hierarchy is one of the neutrino fundamental properties yet to be determined. We introduce a method to determine neutrino mass hierarchy by comparing the events of neutral current (NC) interactions, $\nu(\overline{\nu})+p \rightarrow \nu(\overline{\nu})+p$, and inverse beta decays (IBD), $\bar{\nu}_e+p \rightarrow n+e^+$, of supernova neutrinos from accretion and cooling phases in scintillation detectors. Neutrino flavor conversions inside the supernova are sensitive to neutrino mass hierarchy. Due to Mikheyev-Smirnov-Wolfenstein effects, the full swapping of $\bar{\nu}_e$ flux with the $\bar{\nu}_x$ ($x = \mu,\ \tau$) one occurs in the inverted hierarchy, while such a swapping does not occur in the normal hierarchy. As a result, the ratio of high energy IBD events to NC events for the inverted hierarchy is higher than the ratio for the normal hierarchy. Since the luminosity of $\bar{\nu}_e$ is larger than that of ν_x in accretion phase while the luminosity of $\bar{\nu}_e$ becomes smaller than that of ν_x in cooling phase, we calculate this ratio for both accretion and cooling phases. By analyzing the change of this event ratio from accretion phase to cooling phase, one can determine the neutrino mass hierarchy.

Experimental Collaboration

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