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Detection of supernova ν_e in water Cherenkov and liquid scintillator detectors

We develop a new way to isolate supernova ν_e, using gadolinium-loaded water Cherenkov detectors. The forward-peaked nature of $\nu_e + e^- \to \nu_e + e^-$ allows an angular cut that contains the majority of events. Even in a narrow cone, near-isotropic inverse beta events, $\bar{\nu}_e + p \to e^+ + n$, are a large background. With neutron detection by radiative capture on gadolinium, the background events can be individually identified with high efficiency. The remaining backgrounds are smaller and can be measured separately, so they can be statistically subtracted. Super-Kamiokande with gadolinium could measure the total and average energy of supernova νe with ~ 20% precision or better each (90% C.L.).

The main detection channels for supernova ν_e in a liquid scintillator are its elastic scattering with electrons and its charged-current interaction with the ^{12}C nucleus. In existing scintillator detectors, the numbers of events from these interactions are too small to be very useful. However, at the 20-kton scale planned for the new detectors, these channels become powerful tools for probing the νe emission. We find that the νe spectrum can be well measured, to better than ~40% precision for the total energy and better than ~25% precision for the average energy. This is adequate to distinguish even close average energies, e.g., 11 MeV and 14 MeV, which will test the predictions of supernova models.

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