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The Diffuse Supernova Neutrino Background is Detectable in Super-Kamiokande

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The Diffuse Supernova Neutrino Background (DSNB) provides an immediate opportunity to study the emission of MeV thermal neutrinos from core-collapse supernovae. The DSNB is a powerful probe of stellar and neutrino physics, provided that the core-collapse rate is large enough and that its uncertainty is small enough.

To assess the important physics enabled by the DSNB, we start with the cosmic star formation history (CSFH) of Hopkins & Beacom (2006) and confirm its normalization and evolution by cross-checks with the supernova rate, extragalactic background light, and stellar mass density. We find a sufficient core-collapse rate with small uncertainties that translate into a variation of $\pm 40\%$ in the DSNB event spectrum.

Considering thermal neutrino spectra with effective temperatures between 4–6 MeV, the predicted DSNB is within a factor 4–2 below the upper limit obtained by Super-Kamiokande in 2003. Furthermore, detection prospects would be dramatically improved with a gadolinium-enhanced Super-Kamiokande: the backgrounds would be significantly reduced, the fluxes and uncertainties converge at the lower threshold energy, and the predicted event rate is 1.2–5.6 events/yr in the energy range 10–26 MeV. These results demonstrate the imminent detection of the DSNB by Super-Kamiokande and its exciting prospects for studying stellar and neutrino physics.