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Comprehensive Analyses of the Neutrino-Process in the Core-collapsing Supernova

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We discuss the neutrino flavor change effects due to neutrino self-interaction, shock wave propagation as well as matter effect on the neutrino-process of the core-collapsing supernova (CCSN). For the hydrodynamics, we use two models: a simple thermal bomb model and a specified hydrodynamic model for SN1987A. As a pre-supernova model, we take an updated model adjusted to explain the SN1987A employing recent development of the (n, γ) reaction rates for nuclei near the stability line $(A \sim 100)$. As for the neutrino luminosity, we adopt two different models: equivalent neutrino luminosity and non-equivalent luminosity models. The latter is taken from the synthetic analyses of the CCSN simulation data which involved quantitatively the results obtained by various neutrino transport models. Relevant neutrino-induced reaction rates are calculated by a shell model for light nuclei and a quasi-particle random phase approximation model for heavy nuclei. For each model, we present abundances of the light nuclei (^{7}Li, ^{7}Be, ^{11}B and ^{11}C) and heavy nuclei (^{92}Nb, ^{98}Tc, ^{138}La and ^{180}Ta) produced by the neutrino-process. The light nuclei abundances turn out to be sensitive to the Mikheyev-Smirnov-Wolfenstein (MSW) region around O-Ne-Mg region while the heavy nuclei are mainly produced prior to the MSW region. Through the detailed analyses, we find that neutrino self-interaction becomes a key ingredient in addition to the MSW effect for understanding the neutrino-process and the relevant nuclear abundances. The normal mass hierarchy is shown to be more compatible with the meteorite data. Main nuclear reactions for each nucleus will also be discussed in detail.

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