Neutrino-induced nucleosyntehsis in core-collapse supernovae

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Abstract

Neutrinos play an important role in supernova explosions. The neutrino heating mechanism, in which a shock generated after core bounce is revived by neutrino energy deposition to trigger explosions, has been the working hypothesis among researchers for the modern core-collapse supernova theory. A number of multi-dimensional hydrodynamic simulations have been reported so far, which gives us a confidence that some kinds of hydrodynamic instabilities can help the onset of the neutrino-driven explosion. On the other hand, neutrinos induce some characteristic nucleosynthesis. A small fraction of neutrinos emitted form the central proto-neutron star will interact with stellar materials, excite them, and open new channels in the reaction network or directly produce rare isotopes.

I introduce our latest result of 3-dimensional hydrodynamic simulation for core-collapse supernova. The distribution of physical quantities shows very complicated structure, which enhances the efficiency of neutrino heating. I also review the neutrino-induced nucleosynthesis, in particular the synthesis of light elements (Li and B; [1]-[3]) and of heavy radioactive isotope niobium-92[4]. Li and B isotopes are produced via some processes such as Big Bang Nucleosynthesis, cosmic-ray spallations, and thermonuclear reactions in AGB stars and low-mass giants. ^{7}Li and ^{11}B are synthesized by the neutrino process, for example $^{4}\mathrm{He}(\nu,\nu'p)^{3}\mathrm{H}(\alpha,\gamma)^{7}\mathrm{Li}(\alpha,\gamma)^{11}\mathrm{B}$. For the purpose to examine the properties of supernova neutrino, it is necessary to disentangle the contribution of the neutrino process to these light elements in the Galaxy from the other production sites. On the other hand, some heavy rare isotopes such as ^{138}La and ^{180}Ta are considered to be almost purely coming from the neutrino process. ^{92}Nb, a radioactive isotope with half life of 34.7 Myr, is in the similar condition as the neutrino-processed isotopes ^{138}La and ^{180}Ta in the sense that all of these nuclei are shielded from β^{+}, e^{-} capture, or β^{-} decays. The overabundance of ^{92}Zr detected in meteorites might be a relic of SN neutrino process.

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