Explosive nucleosynthesis in aspherical supernovae of massive stars with the solar and zero metallicity

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We have investigated explosive nucleosynthesis in core-collapse supernovae (SNe) of massive stars, based on two-dimensional (2D) hydrodynamic simulations of the SN explosion. Employing a simplified light-bulb scheme for neutrino transport and excising a central part of a proto-neutron star (PNS), we follow long-term evolution of the SN explosion over 1.0 second after the core bounce for 22 massive stars with masses from 10.8 to $40 M_{\odot}$ and with the solar metallicity and 15 stars with masses from 10 to $40 M_{\odot}$ and with zero metallicity, adopting a PNS core model, with which we evaluate evolution of neutrino luminosities and temperatures as in Ugliano et al. 2012. We adopt two parameter sets of the PNS core model; one results in faster explosion of 0.2-0.4 s after the bounce and the other later explosion of $0.4 - 0.6$ s. Then, we calculate abundance evolution of the SN ejecta through post-processing calculation using a large nuclear reaction network including 463 nuclei from neutron, proton to Kr and evaluate abundances and masses of the SN ejecta.
We find two explosion models of 19.4 and 25.0 $M_{\odot}$ stars ($Z = Z_{\odot}$) whose $E_{\rm exp}$ and M(^{56}Ni) and M(^{57}Ni) are comparable to those observed in SN1987A, only for the PNS core model with the faster explosion. For the progenitors with $Z = Z_{\odot}$ and using the PNS core model with the faster explosion, we well reproduces a correlation between M(^{56}Ni) and $E_{\rm exp}$ observed in Type II-Plateau SNe (Pejcha and Prieto, 2015). Moreover, we have calculated IMF-averaged abundances of the SN ejecta of the $Z = Z_{\odot}$ progenitors and added appropriate amounts of ejecta from Type Ia SN (W7 model of Iwamoto et al. 1999 and $\sim 20\%$ of all SNe) to the IMF-averaged abundances. The resultant abundances are found to be well agree with those in the solar system. Finally, we have calculated IMF-averaged abundances of the SN ejecta of progenitors with $Z = 0$ and find that the IMF-averaged abundances well reproduce averaged abundances of observed in metal-poor stars (Cayrel et al. 2004).