R-process Nucleosynthesis in Jets from Collapsars and Magnetars

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Low electron fraction, Ye, is a key factor for an abundant synthesis of nuclei above the 3rd-peak through a strong r-process in baryon-rich jets from collapsars and magnetars, that is rotating magnetized stars collapsing to a black hole and a neutron star, respectively. In the present study, we examine r-process nucleosynthesis inside the jets ejected from the collapsars and magnetars, with a MHD code, in which the Ye evolution is appropriately taken into account.

As in our previous r-process study in collapsars [1,2], initial conditions of the collapsars and magnetars are taken from spherical models of 40Msun and 25Msun stars [3], respectively, just before their core collapse. We manually add vertical, uniform magnetic fields, B0, and angular velocity with a shell-like distribution. We set B0 = 1e10G and 1e12G, which are much smaller than those in models in which a successful strong r-process has been shown [4,5].

Employed with the MHD code, we calculate the evolution of the jets from the collapsars and magnetars. We then follow the abundance evolution inside the jets, and find that the ejecta through the jets from the collapsars have low Ye < 0.1, while the ejecta from the magnetars Ye > 0.3. Consequently, the strong r-processes, with which the 3rd-peak elements are abundantly produced, proceed only in the collapsars. The ejecta from a collapsar is found to be massive > 0.01Msun and to have a similar profile to the solar r-elements, as in our previous work [2].

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