Neutrino Effects on the r-Process in Black Hole Forming Supernovae

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Abstract

We propose one primary site for the r-process,[1,2] i.e., core-collapse supernovae. Light element enrichment in the r-process results from progenitor stars that lie in the 25-40 solar mass range; these stars are thought to become supernovae by first collapsing to a neutron star, then having fallback onto the nascent neutron star to exceed the maximum mass for a neutron star, producing a black hole.[3] Progenitor stars more massive than 40 solar masses would collapse directly to black holes, adding no r-process material to the interstellar medium, whereas stars less massive than 25 solar masses would expel relatively large amounts to the ISM. In the 25-40 solar mass range some r-process material would be expelled to the ISM through hydrodynamic fluctuations that would produce regions with radial velocities in excess of the black hole escape velocity. The amount of material expelled would vary with the mass of the progenitor star, since the more (less) massive stars would remain as neutron stars for times that approaches zero (infinity). The expulsion of matter into the interstellar medium is heated by neutrino emissions from the proto-neutron star. However, a collapse to a black hole will result in dramatic change in the subsequent heating, and most notably in the r-process of the ejecta. Neutrino luminosity changes in the ensuing r-process have been studied in spherical simulations with approximate turbulent mixing mechanisms.

[1] Boyd, R.N. et al. ApJ 744 (2012) L14.
[2] Boyd, R.N. et al. Proc. OMEG 11 (2011) in press.
[4] Heger, A. et al. ApJ 591 (1992) 288.