R-process in Prompt & Delayed Supernova Explosions

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Recent progress in relativistic nuclear physics for properties of nuclei and nuclear matter at extreme conditions has important implication on studies of collapse-driven supernovae and the associated r-process nucleosynthesis, which is the origin of heavy elements. Having recent experimental data of unstable nuclei, a relativistic EOS table for supernova simulations has been constructed with a relativistic mean field approach[1,2].
We perform numerical simulations of hydrodynamics and nuclear reaction network to study the r-process nucleosynthesis in a prompt supernova explosion[3] and in neutrino-driven winds[4,5] above proto-neutron stars born in supernova explosions, adopting the relativistic EOS table. We show that successful r-process nucleosynthesis can take place in these two scenarios of r-process in collapse-driven supernovae corresponding to different explosion mechanisms from presupernova stars with different masses.
The two scenarios are viable to explain the universal r-process abundance pattern, which is accord with the solar abundance, found in new astronomical observations of r-process elements in extremely-metal poor stars. These findings suggest that the origin of r-process may be the combination of prompt explosions from lower-end massive stars and neutrino-driven winds in delayed explosions from most of massive stars.

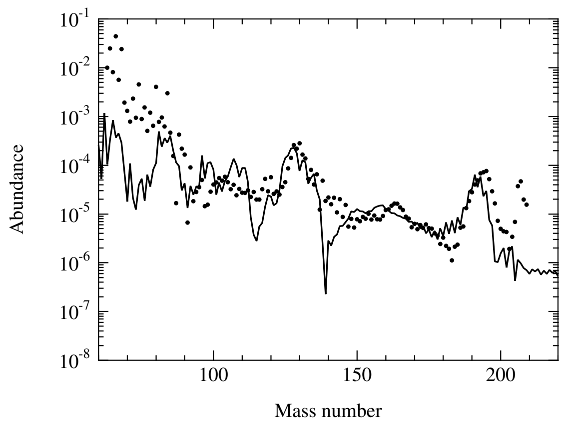

Figure 1: Total abundances of r-process elements in neutron-rich material ejected during a prompt explosion of a $11M_\odot$ star compared with the solar r-process abundances.

References

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