# The r-process Nucleosynthesis in Neutrino-driven Winds Formed by Supernovae

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The r-process is a nucleosynthesis process to produce elements heavier than iron. Neutrino-driven wind from young hot neutron star, which is formed by supernova explosion, is the most promising candidate site for r-process nucleosynthesis. We study general relativistic effects on this wind in Schwarzschild geometry in order to look for suitable conditions for a successful r-process nucleosynthesis. There are key quantities in order to explain the solar system r-process abundances. They are the dynamic time scale of the expansion, $\tau_{dyn}$, the entropy, $S$, and the electron fraction, $Y_e$. Exploring wide parameter region,the protoneutron star masses 1.4-2.0 $M_\odot$ and the neutrino luminosity $10^{50} - 10^{52}$ ergs/s, we find interesting physical conditions which lead to successful r-process nucleosynthesis. The conditions which we found realize in the neutrino-driven wind with very short dynamic time scale $\tau_{\rm dyn} \sim 6$ ms and relatively low entropy $S \sim 140$ (Fig. 1).

We carry out the $\alpha$-process and r-process nucleosynthesis calculation on these conditions by the use of our single network code including over 3000 isotopes, and confirm quantitatively that the second and third r-process abundance peaks are produced in the neutrino-driven wind(Fig. 2,3).

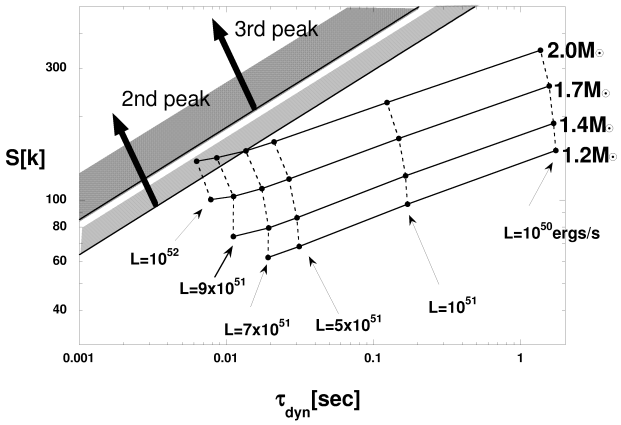


Figure 1: Relation between entropy per baryon S and dynamic time scale $\tau_{dyn}$ for various combinations of the neutron star mass $1.2M_\odot \leq M \leq 2.0M_\odot$ and the neutrino luminosity $10^{50} \leq L_\nu \leq 10^{52}$ ergs/s. Solid and broken lines connect the same mass and luminosity. At the largest end of $L_\nu \sim 10^{52}$ ergs/s for each $M$, there is no solution to satisfy our imposed boundary condition, $T = 0.1$ MeV at $r = 10000$ km. Two zones indicated by shadows satisfy the approximate conditions, for $Y_e = 0.4$, on which the successful r-process occurs (Hoffman et al. 1997) to make the second abundance peak around $A = 130$ (lower) and the third abundance peak around $A = 195$ (upper).

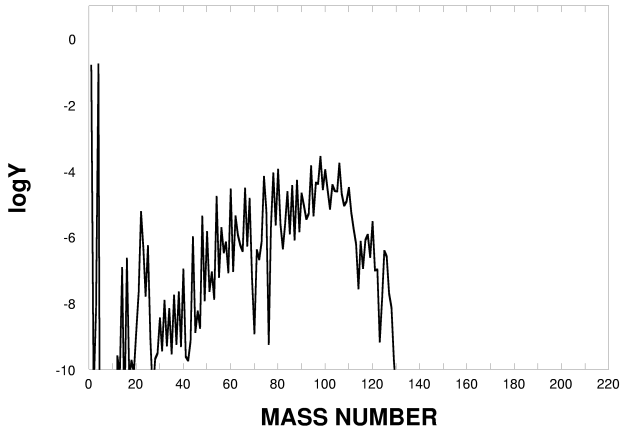


Figure 2: Seed abundances at $T_9 = 2.5$ as a function of atomic number $A$.

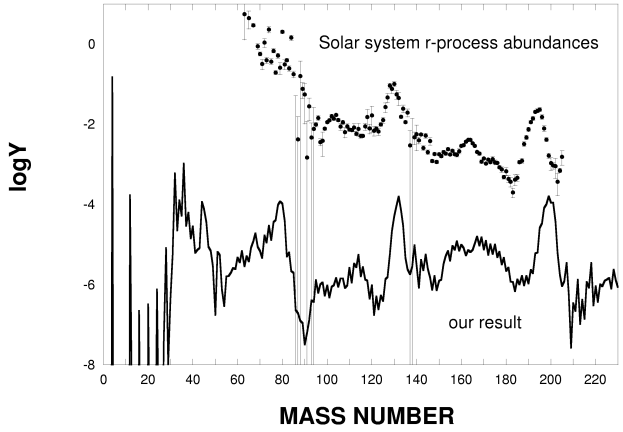


Figure 3: Final r-process abundances (lines) as a function of atomic mass number $A$ compared with the solar system r-process abundances (filled circles) from Käppeler, Beer, & Wisshak (1989). The solar system r-process aubndances are shown in arbitrary unit.

# References

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[3] Hoffman,R.D., Woosley, S.E., and Qian, Y.-Z. 1997, ApJ , 482, 951
[4] Käppeler, F., Beer,H., and Wisshak,K. 1989, Rep.Prog.Phys., 52, 945