Fusion reactions in Supernovae and the early Universe

T. Kajino[1−3], T. Sasaqui[1,2], K. Ichiki[1,2], K. Otsuki[1,4], G. J. Mathews[4], & S. Chiba[3]

[1] *University of Tokyo, Graduate School of Science, Department of Astronomy, Bunkyo-ku, Tokyo 113-0033, Japan*

s [2] *National Astronomical Observatory and Graduate University for Advanced Studies, Mitaka, Tokyo 181-8588, Japan*

[3] *Japan Atomic Energy Research Institute, Advanced Science Research Center, Tokai, Naka, Ibaraki 319-1195, Japan*

[4] *University of Notre Dame, Department of Physics and Center for Astrophysics, Notre Dame, IN 46556-5670, U.S.A.*

The nuclear fusion processes in the early stage of the r-process in supernova explosions are similar to those of the BBN [1]. Even in heavy element production, entropy and density in the neutrino-driven winds are so high that the NSE favors abundant light nuclei. In such an initial explosive condition, many radioactive light-to-intermediate mass nuclei as well as heavy-mass nuclei play the significant roles for the production of heavy r-elements [2]. They are critical for the production of actinides such as ^{232}Th and ^{238}U which are used for cosmochronometers [3]. We will first discuss the roles of relevant radioactive nuclear reactions quantitatively and also their sensitivity to the supernova conditions [4].

Recent WMAP data of cosmic microwave background anisotropy have indicated profound implication in cosmology and nucleosynthesis models: The cosmic expansion seems accelerating for dark energy $\Omega_\Lambda \sim 0.7$ and needs cold dark matter $\Omega_{CDM} \sim 0.27$. There are new theoretical models recently proposed for dark energy [5] and dark matter [6]. Although baryonic fraction $\Omega_b = 0.044 \pm 0.004$ is tiny, Big-Bang nucleosynthesis plays the critical roles in strongly constraining the theoretical models of dark energy and dark matter. WMAP results also limit the cosmic expansion age to $t_U = 13.7 \pm 0.2 Gy$ that should be consistent with the Galactic age inferred from nucleocosmochronometry. We will discuss the similarities and differences between the BBN and the supernova r-process.

References

[1] T. Kajino, K. Otsuki, & M. Orito, Prog. Theor. Phys. Suppl. 146 (2002) 247.

[2] K. Otsuki, H. Tagoshi, T. Kajino, & S. Wanajo, ApJ 533 (2000), 424; M. Terasawa, K. Sumiyoshi, T. Kajino, G. Mathews, & I. Tanihata, ApJ 562 (2001), 470.

[3] K. Otsuki, G. J. Mathews, & T. Kajino, New Astronomy 8 (2003) 767.

[4] T. Sasaqui, K. Otsuki, T. Kajino, G. J. Mathews, & T. Nakamura, (2003), in preparation; K. Otsuki, T. Sasaqui, T. Kajino, & G. J. Mathews, (2003) in preparation.

[5] N. Yahiro, G. J. Mathews, K. Ichiki, T. Kajino, & M. Orito, PRD65 (2002), 063502

[6] K. Ichiki, P. M. Garnavich, T. Kajno, G. J. Mathews, & M. Yahiro, PRD (2003), in press, (astro-ph/0210052); K. Ichiki, M. Yahiro, T. Kajino, M. Orito, & G. J. Mathews, Phys. Rev., D66, 043521 (2002).