Recent Progress in Cosmology and Nuclear Astrophysics

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Recent progress in cosmological deep survey has clarified progressively the origin and distribution of elements and evolution of Galaxies in the Universe. The origin of the light elements in the Big-Bang nucleosynthesis (BBN) has been a topic of broad interest for its significance in constraining the dark matter component in the Universe, and the origin of heavy r-process elements in Supernova (SN) nucleosynthesis has sheds light on clarifying the chemical evolution of the early Galaxy and even knowing the cosmic expansion age. BBN is of particular interest in seeking for the cosmological model which best fits the recent data of cosmic microwave background (CMB) fluctuations [1,2]. It also constrains strongly a new cosmological scanario of the "quintessencial inflation" that is hoped to explain the dark energy component (including cosmological constant Λ) as reqired to account for accelerating universal expansion [3]. Another recent attempts has been made to understand the Einstein gravity in five dimensional Brane world cosmology which is motivated by the superstring theories or M-theory. The BBN makes a strongest constraints on new term of "dark radiation" in Friedmann equation which arises from the extra dimension of this cosmological theory [4].
We will first discuss how the CMB studies help resolve the Ω_b problem [1,2]. Observed CMB power spectrum has exhibited that the flat cosmology is most likely, implying also $\Omega_b h^2 \approx 0.02 \sim 0.04$. Standard homogeneous BBN model predicts $\Omega_b h^2 \leq 0.017$. The baryon inhomogeneous cosmology (inhomogeneous BBN) and lepton-asymmetric Universe models may resolve this potential discrepancy. We will also discuss impacts of BBN on the other cosmological problems [3,4].
The cosmic age problem is another focus in recent years, i.e. the age of the expanding Universe derived from cosmological parameters may be shorter than the age of the oldest globular clusters. We propose to use long lived r-process nuclei like Th and U in the first-generation stars for the age estimate of our Galaxy [5]. For constructing good cosmochronometer we should model the r-process nucleosynthesis in the neutrino-driven wind of core collapse type II Supernovae [6] in the early Galaxy. We will secondly discuss several similarities of the r-process nucleosynthesis in SNe to the Big-Bang nucleosynthesis and also its application to resolve the cosmic age problem [7].

References

[1] M. Orito, T. Kajino, G. Mathews, & R. Boyd, ApJ, submitted (2001), astro-ph/0005446
[2] M. Orito, T. Kajino, G. Mathews, & Y. Wang, PR D, in press (2002)
[3] N. Yahiro, G. J. Mathews, K. Ichiki, T. Kajino, & M. Orito, PR D65, 063502 (2002)
[4] K. Ichiki, M. Yahiro, T. Kajino, M. Orito, & G. J. Mathews, PR D, submitted (2002)
[5] K. Otsuki, et al., contribution to this Conf.
[6] K. Otsuki, H. Tagoshi, T. Kajino, & S. Wanajo, ApJ 533, 424 (2000)
[7] T. Kajino, S. Wanajo, & G. Mathews, NP A, in press (2002); T. Kajino, J. Atom. Nucl. Data. Soc. of Japan, in press (2002)