Nuclear Cosmochronometry and Universality in the r-process Abundance Distribution

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Recent detections of U and Th in metal-deficient stars have raised the possibility that one can use these elements to determine a reliable Galactic age[5][6]. Although Th-Eu cosmochronometer has been used frequently, recent SUBARU-HDS observations of new metal-deficient giants indicate a departure of the Th abundance from a simple extension of the universal solar r-process abundance distribution of heavy neutron-capture elements for 56≤ Z ≤69, based upon these observational data[4]. The Th-Eu chronometer now must be regarded as highly uncertain.
In view of these new data we have made a study of the realizability of the universal solar-system abundance distribution. This study is based upon realistic models for the r-process in the neutrino-heated wind from the hot protoneutron star in a core-collapse TypeII supernova. We found that the abundance ratio of actinide elements to stable elements depends strongly on the physical environment in the neutrino energized wind even though the universal abundances for 56≤ Z ≤69 are reproduced. Nevertheless, We can still find the most likely elemental abundance distribution to produce a reasonable agreement between the ages from the two different cosmochronometers, Th-Eu and U-Th. We also find that the U-Th ratio is almost independent of the wind environment. This is important since it implies chronometer is still viable even if several different environments are also responsible for r-process nucleosynthesis[3].
Furthermore, these observational data for $56 < Z < 69$ element be used to limit the nuclear theoretical uncertainty. We explore which mass formulae and beta-decay rates can satisfactorily reproduce our new observational data of SUBARU/HDS [4].

References

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