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ORIGINAL ARTICLE

The study of s-process nucleosynthesis based on barium stars, CEMP-s and CEMP-r/s stars

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Abstract In order to get a broader view of the s-process nucleosynthesis we study the abundance distribution of heavy elements of 35 barium stars and 24 CEMP-stars, including nine CEMP-s stars and 15 CEMP-r/s stars. The similar distribution of [Pb/hs] between CEMP-s and CEMP-r/s stars indicate that the s-process material of both CEMP-s and CEMP-r/s stars should have a uniform origin, i.e. mass transfer from their predominant AGB companions. For the CEMP-r/s stars, we found that the r-process should provide similar proportional contributes to the second s-peak and the third s-peak elements, and also be responsible for the higher overabundance of heavy elements than those in CEMP-s stars. Which hints that the r-process origin of CEMP-r/s stars should be closely linked to the main r-process. The fact that some small r values exist for both barium and CEMP-s stars, implies that the single exposure event of the s-process nucleosynthesis should be general in a wide metallicity range of our Galaxy. Based on the relation between C_{r} and C_{s}, we suggest that the origin of r-elements for CEMP-r/s stars have more sources. A common scenario is that the formation of the binary system was triggered by only one or a few supernova. In addition, accretion-induced collapse(AIC) or SN 1.5 should be the supplementary scenario, especially for these whose pre-AGB companion with higher mass and smaller orbit radius, which support the higher values of both C_{r} and C_{s}.

Keywords Nucleosynthesis · Abundances · Stars: AGB · Stars: barium

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1 Introduction

Based on whether the timescale for neutron capture is slower or faster than the β-decay timescale for unstable nuclei, the nuclei beyond the iron group are created in neutron-capture processes, i.e. s- (slow) or r- (rapid). The two neutron-capture processes are thought to occur under different physical conditions and therefore likely to arise in different astrophysical sites. The s-process, which requires a lower neutron flux (with a typical neutron-capture taking many years), is generally thought to occur during the double-shell burning phase of asymptotic giant branch (AGB) stars with low- and intermediate-mass (Busso et al. 1999). The r-process requires a high neutron flux level (with many neutron-captures over a timescale of a fraction of a second), which is expected to take place in the exploding astrophysical site or sites such as the ν-driven wind of Type II (i.e. core-collapse) supernovae (Woosley et al. 1994), the mergers of neutron stars (Rosswog et al. 2000), accretion-induced collapse (AIC; Qian and Wasserburg 2003), and Type 1.5 supernovae (Zijlstra 2004) etc.

Low-mass AGB stars are as well known as the main site for the s-process elements producing (Gallino et al. 1998; Lugaro et al. 2003; Herwig 2004; Käppeler et al. 2011; Bisterzo et al. 2011). During their thermally pulsing (TP)