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Comparing the Nucleosynthesis Parameters of s+r Stars and Ba Stars

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Abstract. In this paper, we use a parametric model of the asymptotic giant branch (AGB) stars, in which the ^{13}C neutron source is activated in radiative conditions during the interpulse periods, to calculate the nucleosynthesis in 29 very metal-poor double-enhanced stars (i.e. s+r stars) and 26 barium stars (i.e. Ba stars), respectively. Through a statistical analyzing on the corresponding parameters obtained for the above stars, we get the possible conditions which the s+r stars formed in. We find that the value of neutron exposures of most s+r stars is greater than that of Ba stars. In the very metal-poor stars, the Ba stars stars should belong to the binary systems with large initial orbital separation, by comparing the s-process-component coefficient (C_s) values with those of s+r stars. For s+r stars, there is strong correlation between their C_s and C_r (r-process-component coefficient) but no correlation for Ba stars. This strongly confirms the possibility that the s+r stars should form through the accretion-induced collapse (AIC) or type 1.5 supernova mechanism.

Keywords. nucleosynthesis, stars: abundances, AGB and post-AGB

1. Introduction

It is interesting to adopt the parametric model for metal-poor stars presented by Aoki, Reyan, Norris, *et al.* (2001) and developed by Zhang, Ma, & Zhou (2006) to study the physical conditions that could reproduce the observed abundance pattern. Using the parametric model, we investigate the characteristics of the nucleosynthesis pathway that produces the special abundance ratios of 29 s+r stars and 26 Ba stars, respectively. The calculated results are presented in Sect. 2 in which we also discuss the differences between the parameters of s+r stars and those of Ba stars. Conclusions are given in Sect. 3.

2. Results and Discussion

We explored the origin of the neutron-capture elements in s+r stars and Ba stars. In the parametric model, there are four parameters: the neutron exposure per thermal pulse $\Delta\tau$, the overlap factor r, C_s and C_r. Using the observed data from 29 s+r stars and 26 Ba stars, the model parameters can be obtained from the parametric approach, respectively.

Histograms given in figure 1 show the distribution of the number ratio of s+r stars and that of Ba stars via the nucleosynthesis parameters. From figure 1, We can see that the $\Delta\tau$ values of Ba stars are almost in the range $0 \sim 0.5$ mb^{-1}, but those of s+r stars are almost in the range $0.5 \sim 1.0$ mb^{-1}. The $\Delta\tau$ range of s+r stars ([Fe/H]$\leqslant -2.0$) is obviously greater than that of Ba stars ([Fe/H]> -1.0). This confirms the fact that the neutron density in the nucleosynthesis region increases with declining metallicity (Gallino, Arlandini, Busso, *et al.* 1998; Cui, & Zhang 2006). The right panel in figure 1

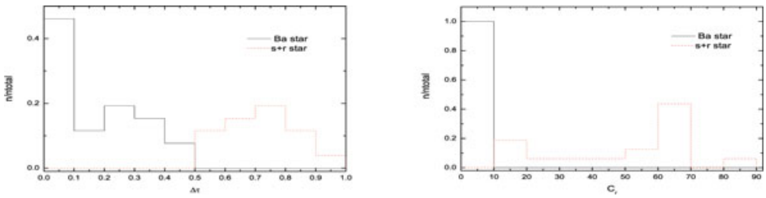

Figure 1. Histograms showing the distribution of the number ratio of s+r stars and that of Ba stars via the nucleosynthesis parameters. Left: via $\Delta\tau$; Right: via C_r.

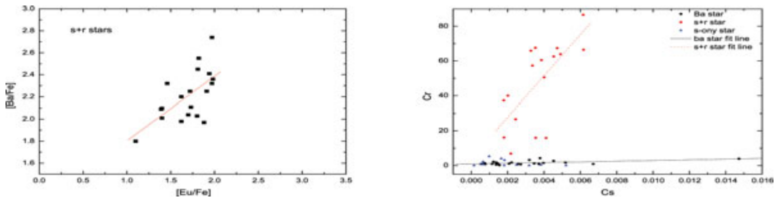

Figure 2. Left: Correlation between [Ba/Fe] and [Eu/Fe]; Right: between C_r and C_s.

shows that the C_r values of Ba stars distribute in a small range $0 \sim 10$, but in a wide range $10 \sim 90$ for s+r stars. Obviously, the C_r values of s+r stars are greater than those of Ba stars which is similar to s-only stars. This implies that there are different origins for the r-process elements between s+r stars and Ba stars. The Ba stars should formed in a normal homogeneous molecular cloud for their low r-process element abundances.From figure 2, we can see that [Ba/Fe] increases with [Eu/Fe], and C_r also increases with C_s for s+r stars. This strongly implies that the s+r stars form in binary systems which should have suffered the AIC or Type 1.5 supernova event. Because if they come through pre-enrichment event, i.e. they form in a nearby molecular cloud polluted by Type II supernova, the abundances of r-process elements will exhibit large spread. For Ba stars and s-only stars, C_r does not increase with C_s, furthermore there is not large spread. This implies that there is not rapid neutron-capture event taking place in the binary systems which Ba stars and s-only stars belong to.

3. Conclusions

In this paper, we carry a statistical analyzing on the nucleosynthesis parameters of 29 s+r stars and 26 Ba stars. We give the possible mechanisms of s+r stars, Ba stars and s-only stars, respectively.

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