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Exploring the nucleosynthesis region of metal-poor Stars

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Abstract. The chemical abundances of the very metal poor double-enhanced stars are excellent information to set new constraints on models of neutron-capture processes at low metallicity. There have been many theoretical studies of s-process nucleosynthesis in low-mass AGB stars. Using the parametric approach based on the radiative s-process nucleosynthesis model, we calculate the following five parameters for a series of metal-poor stars. They are: the mass fraction of ^{13}C pocket q, the overlap factor r, the neutron exposure per interpulse $\Delta\tau$, and the component coefficients that correspond to relative contribution from the s-process and the r-process. We find that the mass fraction of ^{13}C pocket q deduced for the Pb stars is comparable to the overlap factor r, which is about 10 times larger than normal AGB model; $q \sim 0.05$; and the neutron exposure per interpulse $\Delta\tau$ for all Pb stars are about 10 times smaller than the ST case ($\Delta\tau \sim 7.0\text{mb}^{-1}$). Although the two fundamental parameters $\Delta\tau$ and q obtained for the Pb stars are very different from the AGB stellar model, the results of the larger value of q and the smaller value of $\Delta\tau$ can also explain the abundance distribution of the Pb stars. This suggest that the q change to larger than that of normal AGB model. Then, this factor will result in the descent of the density of ^{13}C in the nuclear synthesis region directly. So, the neutron exposure $\Delta\tau$ will also decrease to the same extent. Although the neutron number density in the larger initial mass AGB stars ($m > 3M_\odot$) is high, the neutron irradiation time is shorter, obviously the neutron exposure per interpulse in the AGB stars should be smaller. It is noteworthy that the total amount of ^{13}C in metal poor condition is close to the ST case, which is consistent with the primary nature of the neutron source.

Keywords. Nucleosynthesis, metal-poor Stars

1. Introduction

The elements heavier than the iron peak are made through neutron capture via two principal processes: the r-process and the s-process.

In order to investigate the efficiency and sites of the s- and r-process, the elemental abundances of double-rich stars are particularly useful. There have been many theoretical studies of s-process nucleosynthesis in low-mass AGB stars. Unfortunately, however, the precise mechanism for chemical mixing of protons from the hydrogen-rich envelop into the ^{13}C -rich layer to form ^{13}C-pocket is still unknown. This makes it even harder to understand the particular abundance pattern of the s- and r-process elements found in carbon-rich mental-poor stars.The calculated results and discussion are described in sect.2. The conclusions are given in sect.3.

2. Results and Discussion

There are five parameters in the parametric model on s-process nucleosynthesis: the neutron exposure per pulse, $\Delta\tau$, the mass fraction of ^{13}C pocket in the He intershell q,

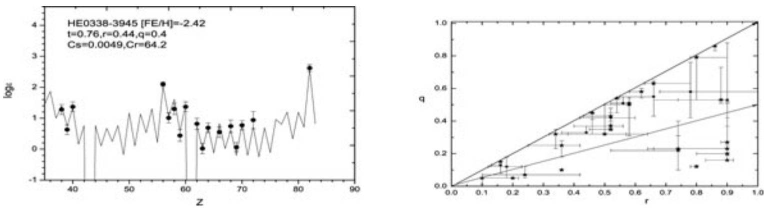

Figure 1. Left: As an example,we show our calculated best-fit results for a CEMP star HE 0338-3945.Right:show our between the mass fraction of ^{13}C pocket in the He intershell q and the overlap factor r is fitted approximately.

overlap factor r,Cs and Cr. We explored the origin of the neutron-capture elements in the double-enhanced stars by comparing the observed abundances with predicted s- and r-process contribution.In the AGB model, the overlap factor r and the neutron exposure per pulse, $\Delta\tau$ are the fundamental parameters.The mass fraction of ^{13}C pocket, q is an important parameter in the radiative s-process nucleosynthesis models.

We find the mass fraction of ^{13}C pocket q deduced for the Pb stars is comparable to the overlap factor r, which is larger than normal AGB model$q \sim 0.05$about 10 times, and the neutron exposure per interpulse $\Delta\tau$ for all Pb stars are smaller than the ST case ($\Delta\tau \sim 7.0\text{mb}^{-1}$)about 10 times. Although the two fundamental parameters $\Delta\tau$ and q obtained for the Pb stars are very different from the AGB stellar model, the results of the larger value of q and the smaller value of $\Delta\tau$ can also explain the abundance distribution of the Pb stars.This suggest that the q change to larger than that of normal AGB model.Then,this factor will result in the descent of the density of ^{13}C in the nuclear synthesis region directly. So, the neutron exposure $\Delta\tau$ will also decrease to the same extent.Although the neutron number density in the larger initial mass AGB stars ($m > 3M_{\odot}$) is high, the neutron irradiation time is shorter, obviously the neutron exposure per interpulse in the AGB stars should be smaller.

3. Conclusions

It is noteworthy that the total amounts of ^{13}C in metal poor condition are close to the ST case, which is consistent with the primary nature of the neutron source.

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