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A Spectroscopic Study of Barium Stars

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Abstract. We present an analysis of eight barium stars, providing their atmospheric parameters ($T_{\rm eff}$, $\log g$, [Fe/H], ξ_t) and chemical abundances, based on the high signal-to-noise ratio and high resolution Echelle spectra. The *s*-process elements Y, Zr, Ba, La, Eu show obvious overabundance relative to the Sun. And Na, Mg, Al, Si, Ca, Sc, Ti, V, Cr, Mn, Ni show comparable abundances to the Solar ones. The results of theoretical model of wind accretion for binary systems can explain the observed abundance patterns of the neutron capture process elements in these Ba stars, which means that their overabundant heavy-elements could be caused by accreting the ejecta of AGB stars, the progenitors of the present white dwarf companions in the binary systems.

Keywords. Stars: abundances — Stars: atmospheres — Stars: chemically peculiar — Stars: evolution — binaries: spectroscopic

1. Introduction

Barium stars appear as a distinct group of chemically peculiar red giants, which show enhanced features of Ba II, Sr II, CH, CN and sometimes C_2 lines. These Ba stars belong to binary systems and could have accreted the matter ejected by their companions (the former AGB stars and now evolved into white dwarfs) about 1×10^6 years ago through wind accretion, disk accretion, or common envelope ejection. The elements heavier than iron are synthesized in the interior of AGB stars through the slow neutron capture process (s-process) (Liang *et al.* 2000). At present, there is a large sample of Ba stars with measurements of orbital elements, absolute magnitudes and kinematics. However, the corresponding heavy-element abundances have not been obtained from high resolution observations. Therefore, we observed the high resolution and high signal-to-noise ratio spectra of Ba stars to obtain their chemical abundances, using the Coudé Echelle Spectrograph of National Astronomical Observatories (NAOC) mounted on the 2.16 m telescope at Xinglong station (Xinglong, P. R. China).

Table 1. Atmospheric parameters of sample stars and heavy element abundances.

HD	$T_{\rm eff}$	$\log g$	ξ_t	[Fe/H]	[Y/Fe]	[Zr/Fe]	[Ba/Fe]	[La/Fe]	[Eu/Fe]
4395	5477	3.60	1.3	−0.16	0.48	0.44	0.53	–	0.43
180622	4391	2.24	1.5	0.21	0.45	0.42	0.45	0.62	0.52
201657	4284	2.17	1.7	−0.31	0.62	0.67	1.21	1.43	0.63
201824	4552	1.67	1.5	−0.40	0.46	0.60	1.27	1.27	0.66
210946	4577	2.42	1.6	−0.22	0.33	0.68	0.81	0.91	0.21
211594	4490	2.44	1.6	−0.23	0.86	0.71	1.26	1.24	0.60
216219	5553	3.64	1.4	−0.34	–	0.87	1.05	1.10	0.49
223617	4501	2.27	1.5	−0.10	0.50	0.65	0.85	1.04	0.53

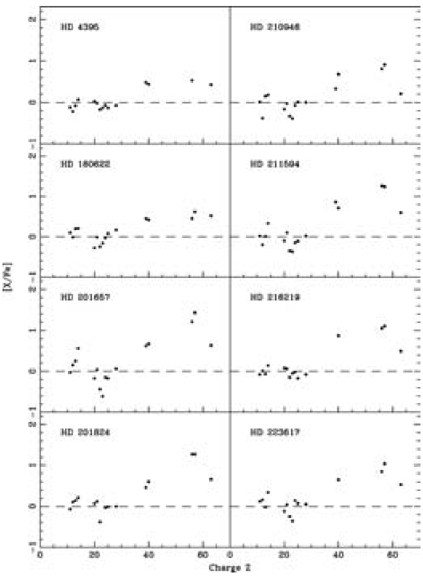

Figure 1. The abundance patterns of sample stars.

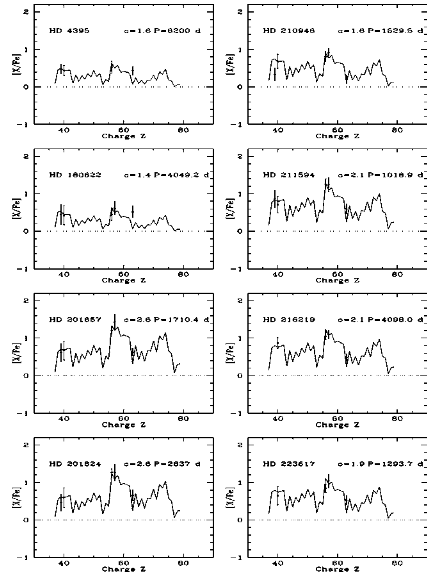

Figure 2. This figure shows the comparisons between theoretical abundances and the observed abundances of the sample stars.

2. Results and Conclusions

We obtain the chemical abundances of eight barium stars based on the input atmospheric parameters (Table 1) and the measured EWs of the absorption lines (see details in Liu *et al.* 2008). The neutron capture process elements Y, Zr, Ba, La, Eu show obvious overabundance relative to the Sun (Figure 1), for example, their [Ba/Fe] values are from 0.45 to 1.27 (Table 1). Other elements, including Na, Mg, Al, Si, Ca, Sc, Ti, V, Cr, Mn, Ni, show comparable abundances to the Solar ones, and their [Fe/H] cover a range from −0.40 to 0.21, which means they belong to disk stars.

The wind accretion model was applied to predict the theoretical heavy element abundances of Ba stars in binary systems, and then compare these theoretical predicts with the observed abundance patterns of our sample stars as shown in Figure 2 (see details in Liang *et al.* 2003). The predicted results by the model can explain well the observed abundance patterns of s-process elements in sample stars with orbital period longer than 1500 (or 1600) days, which is consistent with the suggestions of Jorissen *et al.* (1998). It is interesting to notice that the heavy element abundance patterns of two sample stars with $P > 1000$ days, HD 211594 and HD 223617, can also been explained by wind accretion.

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