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Abundance Ratios in Barium Stars

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Abstract. Abundances of α-, iron peak, s- and r-elements were determined for a sample of Barium stars and the [α,iron peak/s], [α,iron peak/r], [s/r] ratios were derived.

Keywords. Stars: abundances, stars: AGB and post-AGB, nuclear reactions, nucleosynthesis, abundance

1. Introduction

Barium stars belong to a group of peculiar stars identified by Bidelman & Keenan (1951). These stars are G and K giants showing strong lines of s-process elements, particularly Ba II and Sr II, as well as enhanced CH, CN and C_2 bands. The discovery that HR 107, a dwarf star, shows composition similar to that of a mild Barium giant (Tomkin *et al.* (1989)) has pushed the search for new Barium dwarfs.

The temperatures of the sample stars determined from photometric data are in the range 4300 K $<$ $T_{\rm eff}$ $<$ 6500 K. The metallicities derived from Fe I and Fe II lines are in the range -1.2 $<$ [Fe/H] $<$ 0.0, and gravities are 1.4 $<$ log g $<$ 4.6, indicating that the sample includes giants, subgiants and dwarfs.

High-resolution spectra were obtained with the FEROS spectrograph at the ESO-1.5m Telescope. The photometric data were obtained with Fotrap at the Zeiss telescope at LNA (Laboratório Nacional de Astrofísica-Brazil), as well as from the Hipparcos Catalogue, 2MASS (2 Micron All Sky Survey), and The General Catalogue Photometric Data (Geneva system).

2. Abundance Ratios

The abundances were determined by spectrum synthesis of individual lines, using the code described by Barbuy *et al.* (2003).

The results of [X/Fe] obtained for Al, Na, α- and iron peak elements are compatible with the values of [X/Fe] presented in the literature for normal disk stars in the same range of metallicities.

For Na, Al, α and iron peak elements, the relation between [X/Fe] and [Fe/H] is approximately constant in the small range of metallicities of the sample stars. On the other hand, the heavy elements show a higher dispersion which can be explained by the different amounts of enriched material that each star received from its evolved companion. The results for overabundances in s-elements indicate that there is no significant dependence on the luminosity class.

The excesses of Na, Al, α and iron peak elements relative to Ba show a decreasing trend with [Ba/H]. Relations between [X/Ba] and [Fe/H] show an increasing trend. Considering that Ba represents s-process elements, one can consider that these relations describe the relations between s-process and other nucleosynthetic processes. Regarding relations involving the r-process element Eu, there is a range of [Eu/H] where [X/Eu] is essentially

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constant and shows a decreasing trend at the metal-poor end. However, the dispersion does not allow a definitive conclusion. For most stars, [X/Eu] <0, except for Mg, Co and Sc. [X/Eu] x [Fe/H] seems to be constant, with the exception of [Cr/Eu]. The dispersion comes from the fact that stars of different masses produce different amounts of each element. Furthermore, r-elements are not produced in SN Ia, in contrast to most of the other elements. Given that the main component of s-process takes place in a different site (AGB stars), the relation between those elements and Ba does not follow the same pattern. We also conclude that there is no significant dependence of abundances ratios on the luminosity class.

The relations between s- and r-elements for barium stars and post-AGB stars from Reyniers *et al.* (2004) and van Winckel & Reyniers (2000) were used for comparison purposes. The pattern of [X/Eu,Ba] versus [Fe/H] for barium stars is similar to post-AGBs. The dispersion in [Sr/Ba] x [Fe/H] for barium and AGB stars is similar to normal stars as given in Burris *et al.* (2000), suggesting that the abundance of elements relative to the weak component of the s-process is the same for normal, post-AGB and barium stars, and the yield relative to the main component is similar for light and heavy s-elements, keeping the same dispersion of normal stars.

3. s-Process Indexes

The ratios [s/Fe], [ls/Fe], [hs/Fe] and [hs/ls] were determined. We considered for the ls index the light s-elements Sr, Y and Zr, for the hs index the heavy s-elements Ba, La, Ce and Nd and for the s index the light and heavy s-elements.

The results were compared to those from Junqueira & Pereira (2001), Luck & Bond (1991) and North *et al.* (1994). [s/Fe] and [hs/ls] show a decreasing trend for [Fe/H] $>$ -1. However, there is no well-defined trend for [ls/Fe] and [hs/Fe] as a function of [Fe/H].

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