The Barium Abundance in the Young Star RZ Piscium

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Published 2019 November 13 •

Research Notes of the AAS, Volume 3, Number 11

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Received 2019 November 11
Accepted 2019 November 11
Published 2019 November 13

Bihan Shen *et al* 2019 *Res. Notes AAS* **3** 170

https://doi.org/10.3847/2515-5172/ab5647

Young stellar objects ; Stellar abundances

D'Orazi et al. (2009) found a barium overabundance up to 0.6 dex in clusters younger than 200Myr compared to older clusters and the Sun. Oddly, while Ba is found to be overabundant, other s-process elements are not (D'Orazi et al. 2017). The reason for this behavior is still under debate. One hypothesis proposed to explain the high Ba abundance is a different nucleosynthesis mechanism such as the intermediate i-process (Cowan & Rose 1977), but the pattern of Ba overabundance without similar enhancements in other s-process species in young stars still remains a mystery, as does the site of any intermediate i-process. Other possible explanations include chromospheric activity or non-LTE effects.

In this research note, we present our measurement of the abundance of barium in the young star RZ Piscium (RZ Psc), a pre-main sequence star of spectral type G4 and [Fe/H] = −0.1 (Punzi et al. 2018). RZ Psc exhibits extreme optical dropout events and a large infrared excess, indicating its young age and the presence of a dusty disk. Punzi et al. found an age of 30–40Myr, while Potravnov et al. (2019) suggest that RZ Psc may belong to the 20Myr year old Cas-Tau OB association based on its Galactic motion from *Gaia* DR2 astrometric data.

The composition of RZ Psc was analyzed by Punzi et al. (2018) from high dispersion spectra obtained with the Keck I High Resolution Echelle Spectrograph. Punzi et al. describe the observations and reduction procedures. Seven spectra obtained on different dates were co-added to produce a combined spectrum with a S/N of 200. Our spectral coverage includes five features of BaII at 4554, 4934, 5853, 6141, and 6496Å.

The barium abundance of RZ Psc has been derived via spectral synthesis, including the effects of both isotopic shifts and hyperfine structure that contribute to the broadening of barium lines. Synthetic spectra were calculated for each of the five BaII lines present in our spectrum using the MOOG spectrum synthesis program (Sneden 1973, 2017 version). We adopted model atmosphere parameters ($T_{\rm eff}$ = 5600, log$g$ = 4.35, v_T = 2.0, [Fe/H] = −0.11) from Punzi et al. (2018). BaII atomic data were taken from Gallagher (1967) and a solar isotopic mix is assumed. The synthetic spectra were broadened by convolution with a Gaussian function to match the full width at half maximum of other absorption lines near each BaII feature.

We then computed synthetic spectra with a range of the total Ba abundance log ϵ(Ba) to find the best match to the Ba features in our spectrum. The uncertainty of the abundance we derive for each line was determined by eye. We found an abundance of log ϵ(Ba) = 2.2 ± 0.2, 2.8 ± 0.2, 2.2 ± 0.2, 2.4 ± 0.2, and 2.2 ± 0.2 for the 4554, 4934, 5853, 6141, and 6496Å features, respectively, for an average log ϵ(Ba) = 2.36 ± 0.26. Omitting the discrepant 4934 line, which is heavily blended with two strong FeI features, gives log ϵ(Ba) = 2.25 ± 0.10.

In Figure 1, we compare the abundance of barium in RZ Psc with the abundance in young clusters and stellar associations from D'Orazi et al. (2009, 2012), and De Silva et al. (2013). We adopt the solar abundance log ϵ(Ba) = 2.18 from Asplund et al. (2009) to obtain [Ba/Fe] = +0.18 ± 0.15 for RZ Psc. Compared to open clusters and associations of similar age, for which have barium enhancements of order [Ba/Fe] = +0.6 have been reported, RZ Psc does not appear to show any enhancement in the abundance of barium, although the scatter in [Ba/Fe] is large at all metallicities. The source of barium enhancement remains uncertain, but if real, may be related to some stellar parameter other than age.

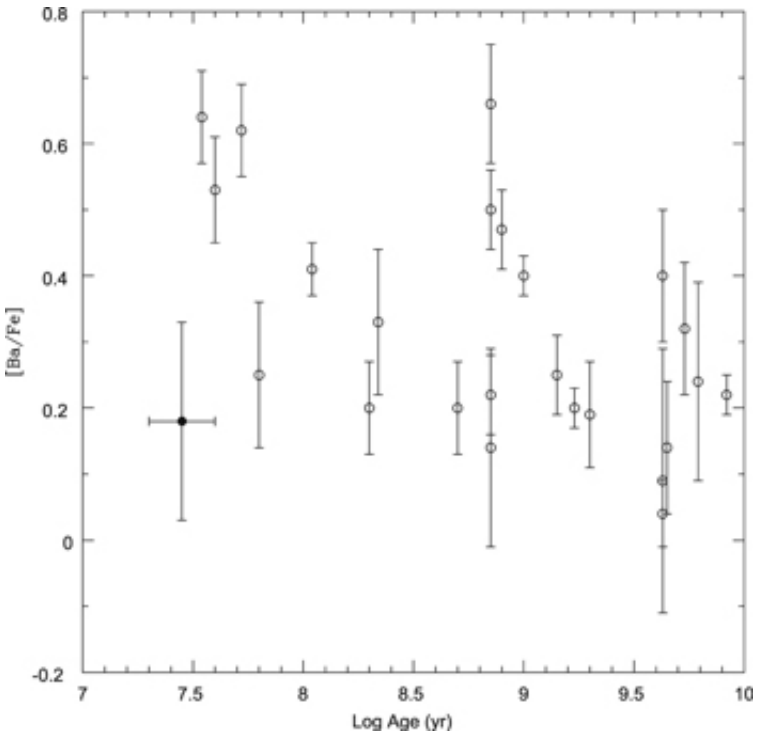

Figure 1. The abundance of barium in RZ Psc (filled circle at Log (age [yr]) = 7.45 ± 0.15) is shown in comparison to measurements from star clusters (open circles) as a function of stellar age. The abundance of barium in RZ Psc does not appear to be consistent with what is observed in young stellar associations.