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Can beryllium abundances be used to estimate stellar ages?

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Abstract. In this work, we present preliminary results of an analysis of Be abundances in a large sample of metal-poor stars from both the Galactic halo and thick disk. We find some evidence of different behavior in the relation log(Be/H) vs. [Fe/H] between stars of the two components, although both are close to the linear relation found in the literature. We discuss the results in connection with the possibility of using abundances of Be as a cosmochronometer, as previously suggested in the literature.

Key words. Stars: abundances – Stars: Population II – Galaxy: halo – Galaxy: thick disk

1. Introduction

The only long-lived isotope of beryllium, ^{9}Be, is neither a product of stellar nucleosynthesis nor produced in a detectable amount by the standard primordial nucleosynthesis. It is a pure product of cosmic-ray spallation (Reeves et al. 1970) involving, mostly, CNO nuclei.

Abundances of Be in metal-poor stars (Molaro et al. 1997; Boesgaard et al. 1999) show a tight linear relation with Fe. Beryllium, therefore, behaves as a primary element. This linear relation is interpreted as evidence that the cosmic-ray composition is independent of the metallicity of the ISM, as first suggested by Duncan et al. (1992).

With a primary production mechanism and assuming cosmic-rays to be globally transported across the Galaxy, the Be abundance may be expected to show a smaller scatter than the products of stellar nucleosynthesis (such as Fe and O) in the early Galaxy (Suzuki et al. 1999; Suzuki & Yoshii 2001). This lead to the suggestion that Be could be a good cosmochronometer for the early stages of the Galaxy (Suzuki & Yoshii 2001).

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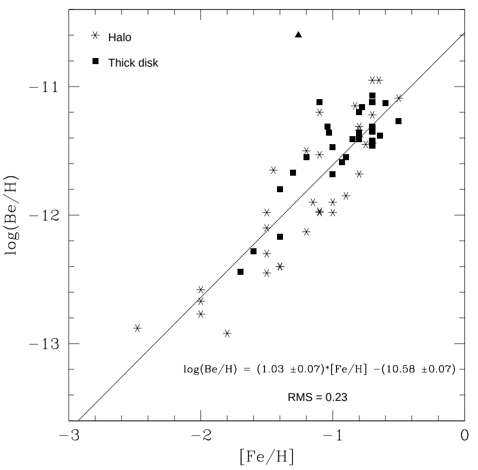

Fig. 1. Diagram of [Fe/H] vs. log (Be/H) for the sample stars. Halo stars are shown as starred symbols and thick disk stars as full squares. The triangle is the beryllium rich star discussed in Smiljanic et al. (2007, submitted). A linear fit to all the halo and thick disk stars is shown.

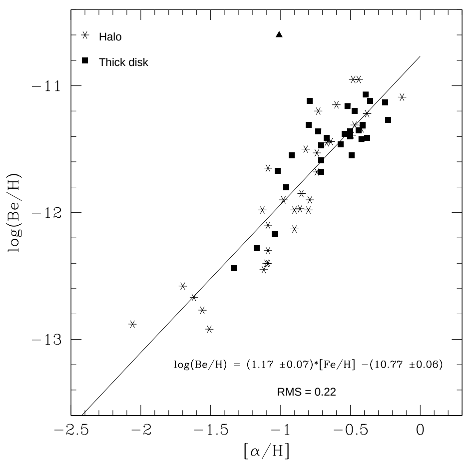

Fig. 2. Diagram of [α/H] vs. log (Be/H) for the sample stars. Symbols are as in Fig. 1. A linear fit to all the halo and thick disk stars is shown.

Pasquini et al. (2004, 2007) detected beryllium in turn-off stars of two globular clusters, NGC 6397 and NGC 6752. They show the Be abundance of these stars to be in good agreement with the abundances of field stars of the same metallicity. Moreover, the ages derived using the Be abundance are in excellent agreement with the ones derived by fitting theoretical isochrones. This result strongly supports the use of Be as a cosmochronometer.

Pasquini et al. (2005) extended this idea to a sample of 20 halo and thick disk stars previously analyzed in the literature (Boesgaard et al. 1999). They show that these stars seem to separate in a log(Be/H) vs. [α/Fe] diagram. Such difference is interpreted as a difference in the time scales of star formation between the halo and the thick disk.

We are currently deriving Be abundances for a large sample of halo and thick disk stars, with the aim of verifying the results of Pasquini et al. (2005). In this work we present some of our preliminary results and discuss some of the implications for the use of Be abundances as a cosmochronometer.

2. Data and analysis

The sample consists of 92 thin disk, thick disk, and halo stars observed with the UVES spectrograph (Dekker et al. 2000) on the ESO VLT at Cerro Paranal, Chile. The spectra have resolving power between 40,000 and 80,000 and were reduced with the UVES pipeline context within MIDAS and EsoRex.

The Be abundances were derived from the Be II lines at 3130.420 Å and 3131.065 Å using spectral synthesis. Details of the analysis will be presented elsewhere (Smiljanic et al. 2007, in preparation).

3. Discussion

Our preliminary results are plotted in figures 1 and 2 as a function of [Fe/H] and [α/H], respectively. In both plots the points follow a linear relation but with a scatter that seems larger than previously found in the literature.

In figures 3 (stars G5-40 and HIP 58962 both with [Fe/H] = -0.80) and 4 (stars HIP 22632 and HIP 53070 both with [Fe/H] = -1.40), we compare the intensity of the BeII lines in stars with similar atmospheric parameters. The difference in the beryllium lines as

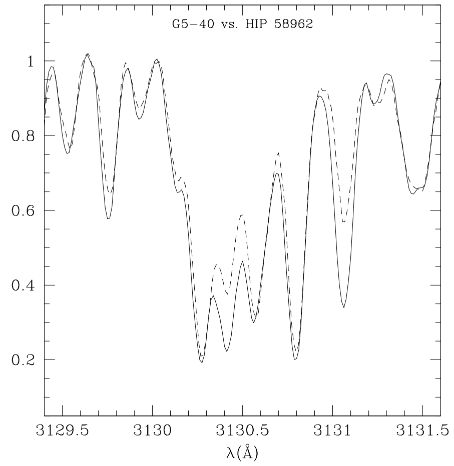

Fig. 3. Comparison of the BeII lines in the stars G5-40 and HIP 58962, which have similar atmospheric parameters.

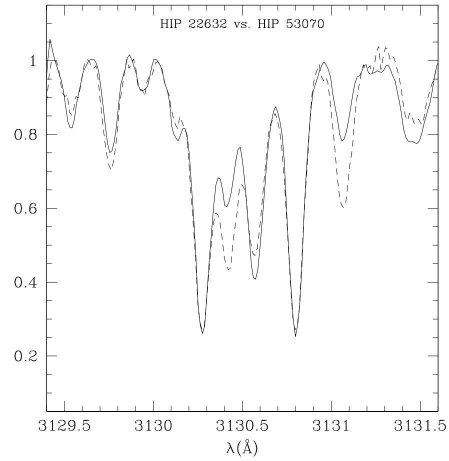

Fig. 4. Comparison of the BeII lines in the stars HIP 22632 and HIP 53070, which have similar atmospheric parameters.

seen in these plots strongly argues that some of the scatter is real.

We note that below [Fe/H] ~ -0.80 halo stars tend to be found below thick disk stars in both figures 1 and 2. This agrees with the expectation that, in the early Galaxy, halo stars reach a higher metallicity earlier than thick disk stars, i.e. at a given time (Be abundance) halo stars have higher mean [Fe/H].

The scatter of the points, however, is large and seems to limit the role of Be as a cosmochronometer. On the other hand, as suggested by Suzuki & Yoshii (2001), the scatter of the abundance of stellar nucleosynthetic products, at a given time in the early Galaxy, might be larger than the scatter of Be. This suggest that Fe might be a larger contributor to the observed scatter than Be. A better understanding of the reality of the scatter and its properties is important to determine whether beryllium might be a reliable cosmochronometer.

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