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HD 232 862 : a magnetic and lithium-rich giant star

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Abstract. Using spectropolarimetric data acquired with the ESPaDOnS and NARVAL instruments at CFHT and at TBL, we present a detailed spectral synthesis analysis of HD 232 862, a field giant classified as a G8II star hosting a magnetic field. This star is the first lithium-rich field giant hosting a magnetic field. Stellar evolution models suggest that HD 232 862 should be a 1.5 to 2.0 $M_\odot$ star at the bottom of the red giant branch. Its unsually high lithium content (A(Li) = 2.45 ± 0.25 dex) is even more puzzling and challenges our understanding of the evolution of this star.

Keywords. Stars: spectroscopy, spectropolarimetry, abundances, evolution, magnetic fields

1. Observations and main features

HD 232 862 is classified as a G8II star in the SIMBAD database. This corresponds to a bright giant star in the mass range [2.5 $M_\odot$; 9 $M_\odot$]. With no Hipparcos parallax, a better determination of its mass and evolutionary status is not available in the literature. HD 232 862 presents several intriguing features : **(a)** rotational velocity v sini = 20.6 km/s, ten times larger than the mean value for luminosity class II objects (de Medeiros & Mayor 1999); **(b)** is an X-ray source in the ROSAT database and presents coronal and chromospheric actiity (IUE spectra); **(c)** is a visually tight binary (Couteau 1988).

The spectropolarimetric data acquired with ESPaDOnS (CFHT, Hawaii) in circular polarization mode between the 7 and 10 Dec. 2006, allowed us to characterize the Stokes V and I parameters. We could detect a complex and time-variable Stokes V profile, pointing to the existence of a magnetic field at the surface of this moderate rotating giant. On the other hand, thanks to the subarcsec conditions reached, we were able to separate the components of the binary and obtain the first high resolution and high S/N spectra for the main component alone. MARCS models atmospheres (Gustafsson *et al.* 2008) were used to derive the following fundamental parameters and Li abundance : T_{eff} = 5000 ± 250 K, log g = 3.0 ± 0.5, [Fe/H] = –0.3 ±0.1 dex, A(Li) = 2.45 ± 0.2 dex.

2. Evolutionary status

Lacking from any parallax, we use the gravity and temperature derived from the spectral synthesis to estimate the mass and evolutionary status of HD 232 862. To do so we use a grid of standard stellar evolution models computed with the STAREVOL code,

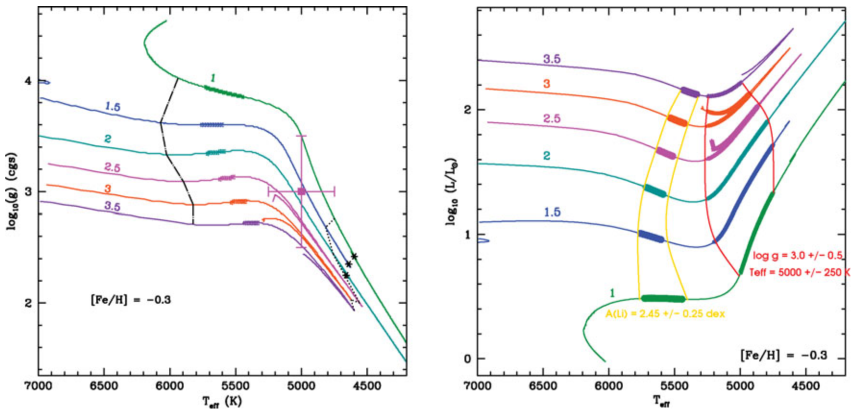

Figure 1. Evolutionary status of HD 232 862. *Left:* Dashed (left) and dotted (right) lines on the figure indicate the beginning and the end of the first dredge-up resp. The asterisks indicate the position of the bump. The bold parts on the tracks indicate the location where A(Li) $\in$ [2.7; 2.2] dex.

with masses ranging from 1 $M_\odot$ to 3.5 $M_\odot$. No diffusion, rotation nor magnetic fields are included in these models. We adopt [Fe/H] = –0.3, $A(Li)_{init}$ = 2.976 dex and Grevesse & Sauval (1998) for the solar chemical composition. Figure 1 shows the (T_{eff}, log g) diagram. HD 232 862 appears to be undergoing the first dredge-up. During this phase, the deepening convective envelope reaches regions where lithium is depleted by nuclear processes, and in the temperature and gravity range estimated for HD 232 862, the surface abundance of this nuclide is predicted to have dropped by a factor of 60 to 100 (depending on the stellar mass), in contradiction with the determined abundance of A(Li) = 2.45 $\pm$ 0.25 dex. Marking the regions in the theoretical HR diagram, where the surface Li abundance and (T_{eff}, log g) vary within the derived errorbars (Fig 1 right), we can see that there is no overlap of these regions : standard stellar evolution models cannot account for the high Li abundance found in HD 232862.

HD 232 862 appears to be a giant, more likely of luminosity class III, at the bottom of the red giant branch. Its surface gravity and effective temperature indicate a mass between 1 and 3.5 $M_\odot$. The high lithium abundance found at its surface is incompatible with the predictions of standard stellar evolution. It is even more intriguing since HD 232 862 should be at the end of the first dredge-up, a stage where the surface Li drops dramatically. As a comparison, the other known Li-rich giants are either at the beginning of the first dregde-up, or at the bump, an evolutionary point well beyond that of HD 232 862. HD 232 862 is also the first Li-rich giant with a detected surface magnetic field. This, together with its binary status, could be important to explain the unusual Li abundance of this star.

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