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LONG-TERM MAGNETIC FIELD MONITORING OF THE SUN-LIKE STAR ξ BOOTIS A

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Abstract. Phase-resolved observations of the solar-type star ξ Bootis A were obtained using the Narval spectropolarimeter at Telescope Bernard Lyot (Pic du Midi, France) during years 2007, 2008, 2009 and 2010. The data sets enable us to study both the rotational and the long-term evolution of various activity tracers. Here, we focus on the large-scale photospheric magnetic field (reconstructed by Zeeman-Doppler Imaging), the Zeeman broadening of the FeI 846.84 nm magnetic line, and the chromospheric CaII H and Hα emission.

Keywords: stars : activity - stars : chromospheres - stars : imaging - stars : magnetic field - stars : solar-type - stars : individual : ξ Bootis A

1 Magnetic field m

Using a line-list matching a stellar photospheric model for the spectral type of ξ Bootis A (G8), we calculated from the observed spectrum a single, averaged photospheric line profile using the LSD multi-line technique (Donati et al. (1997)). Thanks to this cross-correlation method, the noise level of the mean Stokes V line profile is reduced by a factor of about 30 with respect to the initial spectrum. The resulting noise levels are in the range 3.10^{-5}-1.6^{-4} I_c (where I_c denotes the intensity of continuum).

Assuming that the observed temporal varaibility of Stokes V profiles is controlled by the stellar rotation, we reconstructed the magnetic geometry of our star by means of Zeeman-Doppler Imaging (ZDI). We employ here the modelling approach of Donati & Brown (1997), including also the spherical harmonics expansion of the surface magnetic field implemented by Donati et al. (2006) in order to easily distinguish between the poloidal and toroidal components of the reconstructed magnetic field distribution.

The global mean field is around 64.4 Gauss in 2007, 19.2 in 2008, 28.8 in 2009 and 16.1 in 2010. The fraction of poloidal field (wrt toroidal field) is 18% in 2007, 56% in 2008, 35% in 2009 and 63% in 2010.

2 Chromospheric activity (CaII H and Hα)

To study the evolution of the chromospheric CaII H emission during a rotation period, we calculated an emission index from our sets of Stokes I spectra with the method described in Wright et al. (2004) (Fig. 1). The index globally decreased between 2007 and 2010 (the mean values for the four years are respectively 0.413, 0.387, 0.390 and 0.366). A rotational modulation is clearly observed in 2008 and 2010. We also reconstructed an index to monitor the evolution of the chromospheric Hα emission using the same passbands as Gizis et al. (2002). A very good correlation (about 0.85) appears between the Hα and the CaII H index.

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3 Zeeman broadening

We computed the Zeeman broadening by determining the width of a FeI magnetic line (λ = 846.84 nm, g = 2.493) for each intensity spectrum and we observed a decrease between each year. Moreover, there is a correlation of 0.86 between the CaII H activity indicator and the widths of the magnetic line for the whole data set (Fig. 1). We note that such correlation does not exist between the chromospheric index and the width of a neighbouring line with a weak Landé factor.

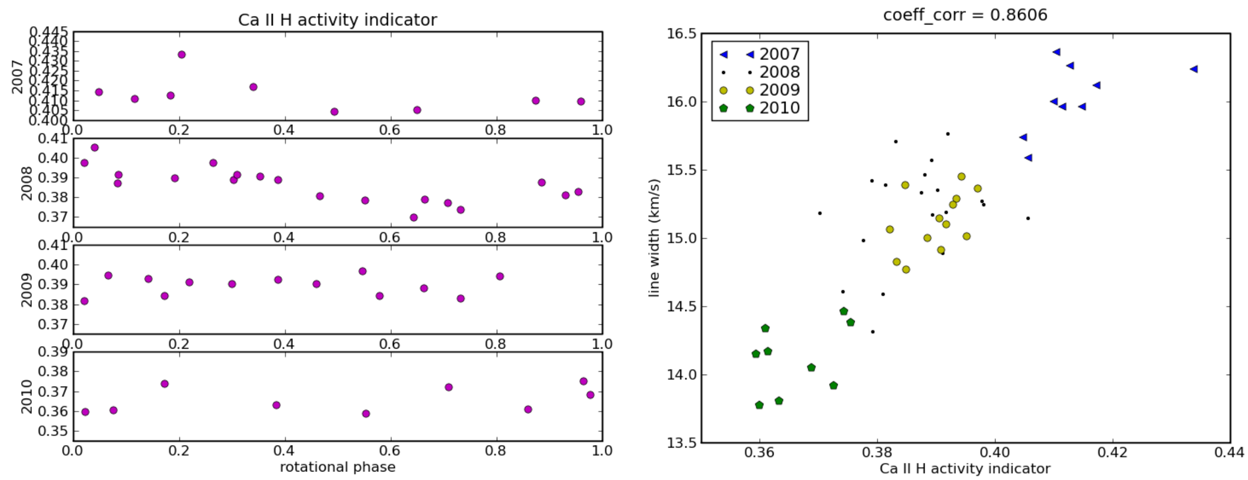

Fig. 1. Left : CaII H activity indicator as a function of the rotational phase for 2007, 2008, 2009 and 2010 (from top to bottom). Right : correlation between the widths of the FeI 846.84 nm magnetic line and the values of the CaII H index.

4 Discussion

An obvious decrease of the global magnetic field is visible between 2007 and 2010. The same kind of variations occurred for the CaII H and Hα index during the same period, as for the width of our magnetic line. In the same time, the fraction of poloidal field increased of 45%, which indicates a significant change in the geometry of the field. ξ Bootis A did not show recent dramatical changes like the magnetic polarity reversals recently reported for HD190771 (Petit et al. (2009)) or τ Bootis (Fares et al. (2009)). Future monitoring of the star will tell us wether its magnetic evolution is associated to some kind of cyclicity, and if its global magnetic field can undergo polarity switches, as observed on more massive solar-type stars up to now.

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