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ARE THERE MAGNETICALLY ACTIVE M GIANTS?

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Abstract. We report first results of magnetic field observations of nine M giants, known for having a relatively fast rotation or/and large X-ray emission. In the HRD, these stars are situated either near the tip of the RGB or high on the AGB, covering the mass range of 1 to 4 $M_{\odot}$.

The observations were carried out at the 2-m Bernard Lyot Telescope of the Pic du Midi observatory, using the NARVAL spectropolarimeter. For two of the stars, EK Boo and β And, definite and marginal Zeeman detections were achieved, respectively. The longitudinal magnetic field (B_l) of EK Boo varied between 0 and -8 G, B_l of β And measured -0.95 +/- 0.16 G. For the other seven giants, only a short observing period was available, and no magnetic field was detected.

More observations will answer the question, whether the detected magnetic field in EK Boo is just a special case. Or is this star the "tip of the iceberg" of magnetically active M giants?

1. INTRODUCTION

Recently, we succeeded in magnetic field detections of single G and K giants with measurements of high accuracy (Konstantinova-Antova et al. 2008a, Aurière et al. 2008, Konstantinova-Antova et al.2009, Aurière et al. 2009). But M giants are not yet known in this respect. There is only sparse and indirect evidence for magnetic activity in such stars (Hünsch et al. 1998, Karovska et al. 2005, Herpin et al. 2006) – despite the theoretical predictions of a possible dynamo operation on the Asymptotic Giant Branch (AGB), see Soker and Zoabi 2002, Nordhaus et al. 2008, Brandenburg 2001. Here we present first results of magnetic field measurements of 9 single M giants. This work is part of a program for the detection of magnetic field in evolved single stars (Konstantinova-Antova et al. 2008b).

Table 1: Data for the observed M giants.

Star	Sp class	$vsini$ km s^{-1}	logL_x	Date	N^o. exp.	Detection	B_l G	σ G
HD130144	M5III	11.3	30.30 - 31.15	See Table 2		DD		
HD6860	M0III	5.6		16 + 26 Sep.08	14	MD	-0.95	0.16
				24 Sep. 09	16	nd	-0.29	0.10
HD16058	M3III	5.4	30.8	20 + 21 Sep.08	5	nd	-0.68	0.38
				20 Dec. 08	3	nd	-1.05	0.59
HD18191	M6III	9.6		16 + 21 Sep.08	5	nd	-0.89	0.45
HD150450	M2.5III	2.5	29.41	19 + 30 Sep.08	8	nd	-0.37	0.19
				25 Feb.09	4	nd	-0.01	0.31
HD167006	M3III	5.2		16 + 21 Sep.08	12	nd	-0.85	0.32
				21 May 09	16	nd	0.97	0.39
HD184786	M5III	7.8		15 + 25 Sep.08	8	nd	-0.16	0.34
HD187372	M2III	4.4	30.64	19 + 29 Sep.08	8	nd	0.31	0.34
				25 Feb.09	4	nd	-0.24	0.47
HD219734	M2III	4.9		15 + 30 Sep.08	8	nd	-0.28	0.30

Individual columns name the star by its HD number and give spectral class, $vsini$, X-ray luminosity (in erg /s, logarithmic), dates of the NARVAL observations, number of exposures, type of detection (DD = definite, MD = marginal, nd = no), B_l, and its error (both in G).

Table 2: NARVAL observations of the magnetic field and activity of EK Boo.

Date	HJD 2450000+	Detection	B$_l$ G	σ G	CaII K
03 Apr 08	4560.50	DD	-6.7	1.8	0.39
04 Apr 08	4561.53	DD	-3.1	0.5	0.39
05 Apr 08	4562.54	DD	-5.0	0.5	0.40
06 Apr 08	4563.51	DD	-4.7	0.7	0.36
20 Dec 08	4821.74	nd	-0.1	0.6	0.46
21 Dec 08	4822.74	nd	-0.5	0.6	0.49
25 Feb 09	4888.6	DD	-0.3	0.4	0.57
09 Mar 09	4900.57	DD	-3.8	0.6	0.55
13 Mar 09	4904.68	DD	-4.6	0.4	0.56
18 Mar 09	4909.55	DD	-8.1	0.6	0.57

Individual columns list dates and HJD, type of detection (DD = definite, nd = no), B$_l$ measurements and its error (both in G), and the normalised CaII K chromospheric line emission, I(CaII K)/I(3950).

2. OBSERVATIONS

The observations were carried out at the 2-m Bernard Lyot Telescope of the Pic du Midi observatory, using NARVAL, a new generation spectropolarimeter (Aurière 2003). NARVAL is a fiber-fed echelle spectrograph, which covers the whole spectrum from 370 nm to 1000 nm in a single CCD exposure. We used NARVAL in its polarimetric mode with a spectral resolution of about 65000. Stokes I (unpolarised) and Stokes V (circular polarization) parameters were measured by means of 4 sub-exposures, between which the retarders, Fresnel rhombus, were rotated. This exchange of the beams in the instrument serves to reduce artificial polarization signatures. For the extraction of the spectra we used Libre-ESpRIT (Donati et al. 1997), a fully automatic reduction package. In the Zeeman analysis, the Least-Squares Deconvolution technique (LSD, Donati et al. 1997) was applied to all observations.

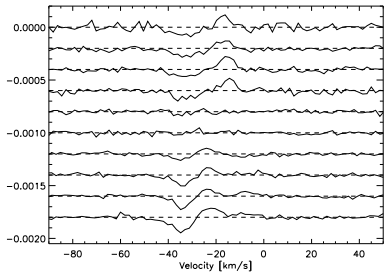

Figure 1: LSD Stokes V profiles for EK Boo in the nights listed by Table 2, from 03 Apr 08 (top) to 18 Mar 09 (bottom); dashed lines show the respective zero levels. The scale of the Y-axis is in units of V/I_c (I_c = intensity of the continuum), but successive profiles are shifted vertically for clarity of the display.

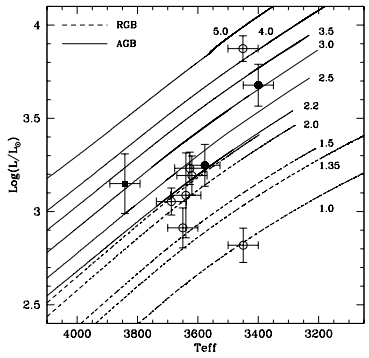

Figure 2: Position in the HR-diagramme of EK Boo and the other M giants studied here, using data of the Vizier (T_{eff}) and 1997 Hipparcos catalogues (V), parallaxes from the New Reduction Hipparcos catalogue (van Leeuwen 2007), and BC according to Buzzoni et al. (2010). For EK Boo two positions (filled circles) are given for alternative values of T_{eff}. β And is represented by a filled square, lines show evolutionary tracks for solar composition (Lagarde and Charbonnel, in preparation).

The target stars were selected on the basis of their relatively fast rotation (Zamanov et al. 2008) and/or high X-ray emission (Hünsch et al. 2004). Most of these stars were observed only in a short period. EK Boo = HD130144, however, was studied in the period of April 2008 to March 2009. Data for the selected M giants and their observations are presented in Table1.

3. RESULTS

Our observations of EK Boo clearly demonstrate the existence of a magnetic field and its variability. This star is a M5 giant (V = 5.6 mag) with a mass of about 2.5 $M_\odot$, according to its position in the HRD. Its magnetic field variability is shown in Table 2 and Fig. 1.

For β And = HD6860, a M0 giant, a marginal detection of magnetic field was achieved in September 2008, B_l measures -0.95 +/- 0.16 G. No detections were obtained in the short observing period available for the remaining seven M giants.

The evolutionary status of our sample stars was determined on the basis of the Vizier catalogue, their Hipparcos parallaxes, bolometric corrections (BC) according to Buzzoni et al. (2010), and assuming solar chemical composition. The resulting HRD positions were compared with evolutionary tracks by Lagarde and Charbonnel (in prep.), see Fig. 2. We find that the M giants are situated near the tip of the RGB or relatively high on the AGB, mostly with masses between 1.5 and 4 $M_{\odot}$. EK Boo lies in the mass range of 2.0 to 3.5 $M_{\odot}$, either on the AGB or at the tip of the RGB. β And has of about 3 $M_{\odot}$ and is an AGB giant.

In the future, more observations will answer the question, whether the detected magnetic field of EK Boo is a special case, or whether we will find a growing number of magnetically active M giants.

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