Magnetic field variability in RZ Ari – an evolved M giant

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Introduction

M giants weren't known to possess magnetic fields. Nevertheless, the theoretical predictions for dynamo operation on the Asymptotic Giant Branch (AGB), (Soker&Zoabi, 2002; Nordhaus et al. 2008, Brandenburg 2002), the data on magnetic activity in such stars were sparse and indirect (Huensch et al. 1998; Karovska et al. 2005; Herpin et al. 2006). We obtained direct Zeeman detections and measured with a high accuracy the longitudinal magnetic field in single M giants (Konstantinova-Antova et al. 2010; 2013; 2014).

Here we present the results of about 10 years magnetic field study of RZ Ari – a single M giant with fast rotation.

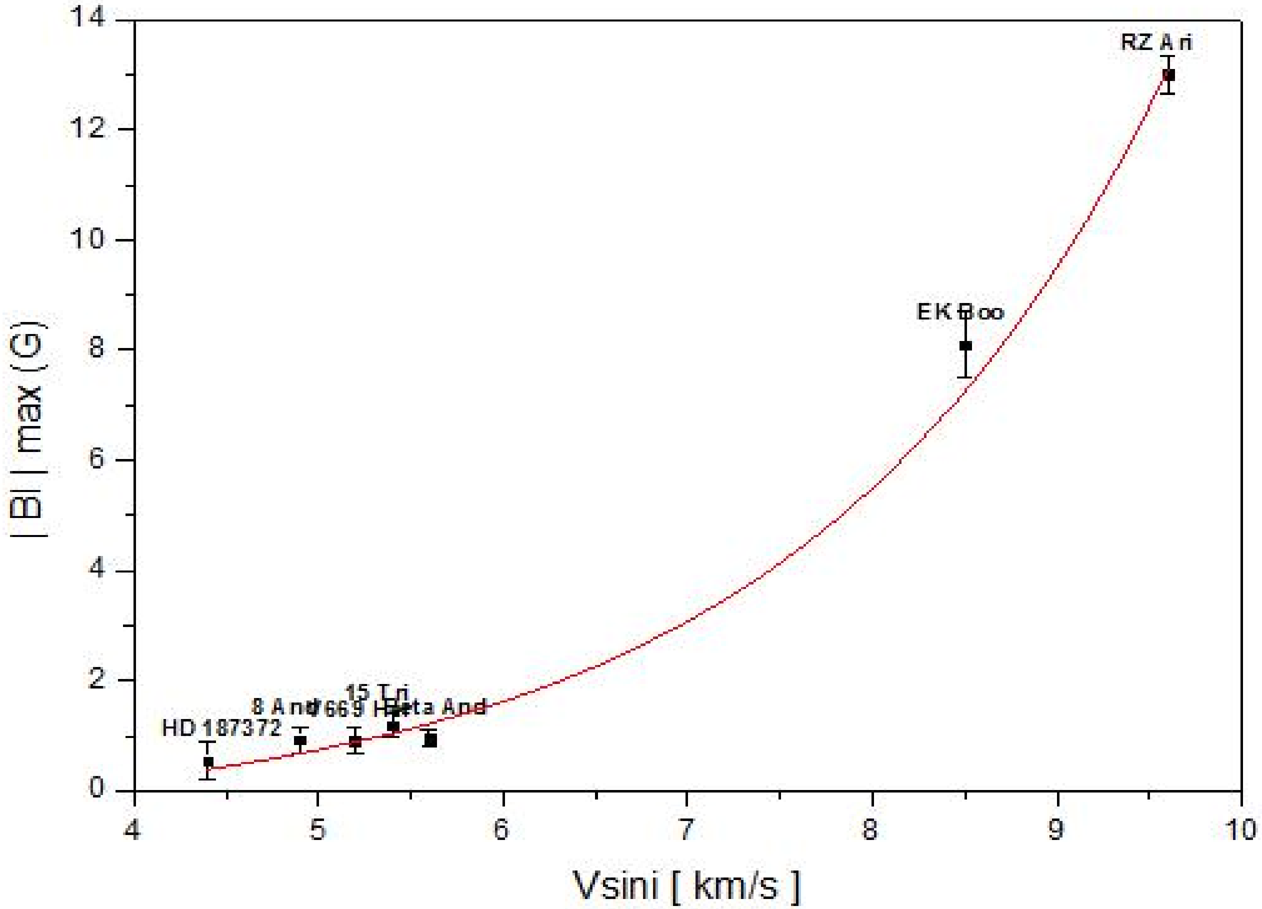
Our first sample single M giants

The M giants were selected on the basis of their faster rotation (Zamanov et al. 2008) and X-ray emission (Hunsch et al. 1998;2004). These stars were observed with Narval spectropolarimeter since 2008. Data for them are presented below (Konstantinova-Antova et al. 2013).

Star	Other Name	Sp class	vsini km/s	log Lx	Detection	Bl max G	σ G
HD130144	EK Boo	M5III	8.5	30.30-31.50	DD	-8.10	0.60
HD6860	beta And	M0III	5.6		DD	-0.95	0.16
HD16058	15 Tri	M3III	5.4	30.80	DD	1.19	0.21
HD18191	RZ Ari	M6III	9.6		DD	13.01	0.33
HD150450	42 Her	M2.5III	2.5	29.41	nd		
HD167006	V669 Her	M3III	5.2		DD	-0.90	0.24
HD184786	V1743 Cyg	M5III	7.8		nd		
HD187372		M2III	4.4	30.64	MD	0.54	0.34
HD219734	8 And	M2III	4.9		MD	-0.93	0.24

RZ Ari is the star with largest Vsini and strongest MF in our sample!

Rotation



Konstantinova-Antova et al. 2013

Observations and methods

2-m Bernard Lyot Telescope (TBL),Pic du Midi with NARVAL spectropolarimeter (Auriere 2003).
NARVAL was used in polarimetric mode with a spectral resolution of about 65000.
Stokes I (unpolarised) and Stokes V (circular polarization) parameters were obtained.
The extraction of the spectra was performed using Libre-ESpRIT (Donati et al. 1997), a fully automatic reduction package installed at TBL.
For the Zeeman analysis, Least-Squares Deconvolution (LSD, Donati et al. 1997) was applied to all the reduced spectra.
Bl is measured on the basis of Stokes V and I profiles (Riess & Semel 1979).

RZ Ari = HD 18191:

Sp class: M6 III

Teff=3450 K, log (L/Lsun) = 3.11

Vsini = 9.6 km/s

M ~ 2.2 Msun => either tip RBG or AGB

(Konstantinova-Antova et al. 2010)

RZ Ari – additional data:

SRb variable star - P~50d; LSP~480d

(Percy et al. 2008; 2016; Tabur et al. 2009)

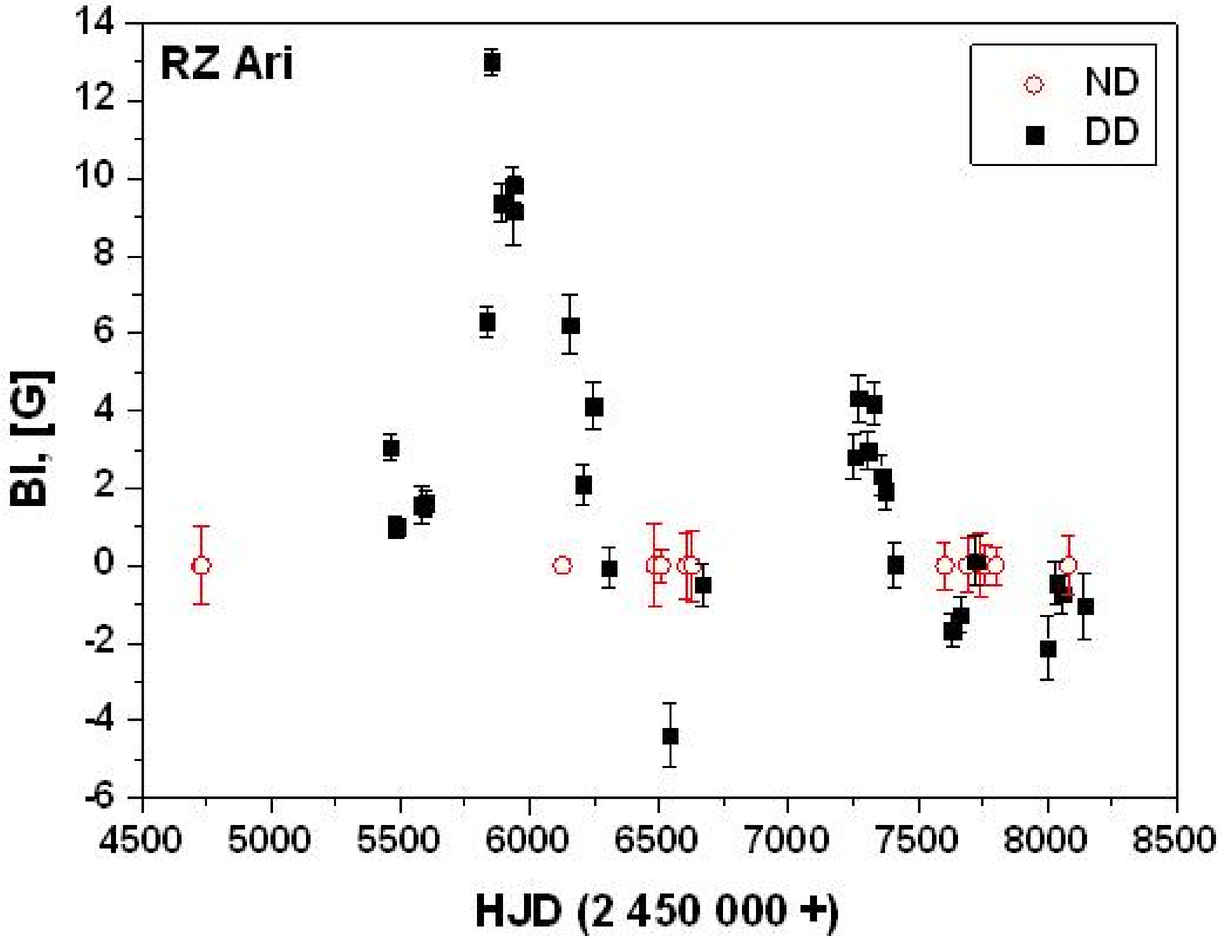
Angular diameter d – 0.01022 arcsec (Richichi et al.2006)

Distance r – 107.76 pc (Hipparcos; van Leeuwen, 2007)

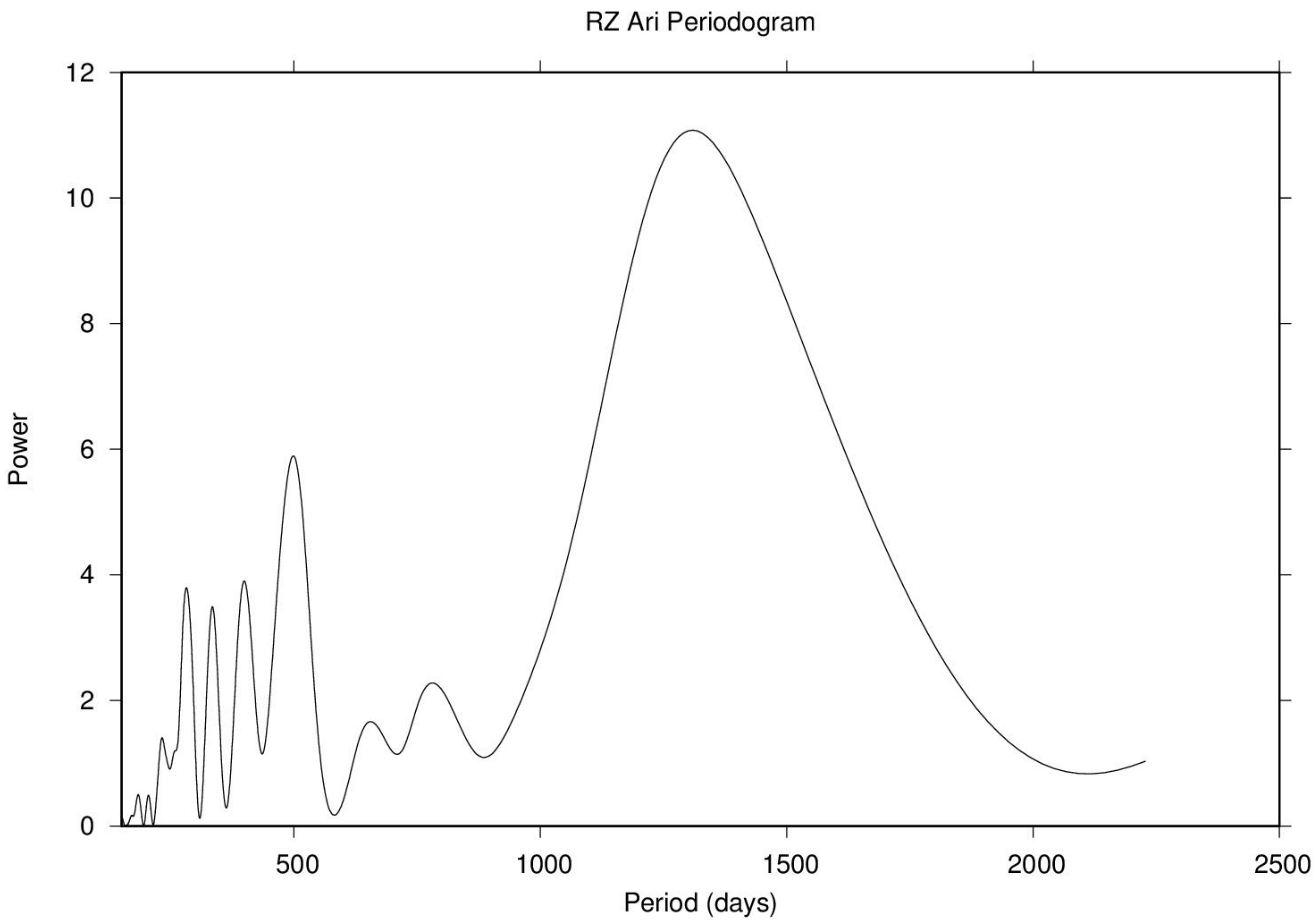
R*= tg (d/2) x r = 117.2 Rsun – consistent with AGB phase

RZ Ari – Bl variability

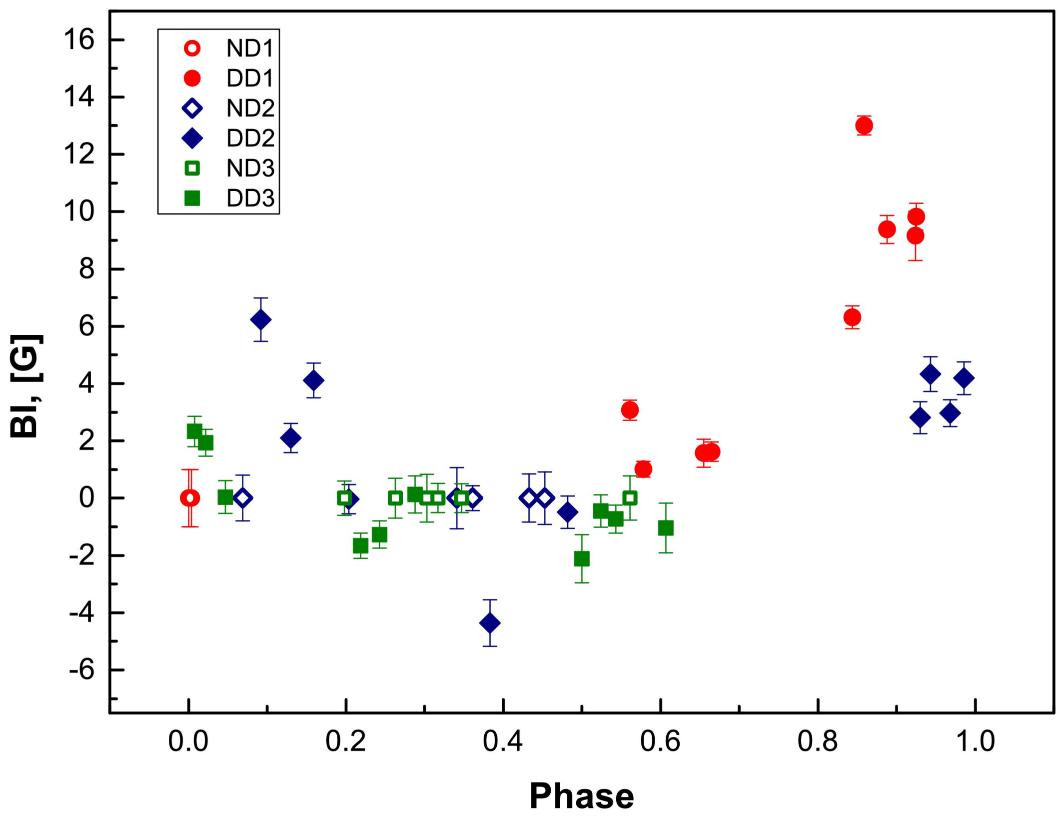
Sept. 2008 – Jan. 2018



RZ Ari – period: Lomb-Scargle
1310 days, +85/-73 days, fap 0.3%
LSP identified: 498d +8/-5d fap 35%



RZ Ari – phased Bl variability:
P= 1310 d



Future prospects:

- ZDI for RZ Ari
- identification of the LSP contribution to the MF variability;
- further quasi-simultaneous observations – spectropolarimetry + photometry desirable

Discussion

1.Where early AGB stars stand in the context of the MF evolution:

After MS in intermediate mass stars convective envelope begins to develop. MFs are detected in Hertzsprung gap stars, at the base of the RGB and He-burning region on HRD and in tip RGB/ early AGB stars. Two reasons for their MF – either dynamo or Ap star descendants (Konstantinova-Antova et al. 2013; Auriere et al. 2015; Charbonnel et al. 2017).

Later stage – AGB pulsating stars (Mira type star chi Cyg, Lebre et al. 2014). Weak MFs near max brightness detected as a result of shock wave propagation

Work hypothesis: early AGB stars are a case of transition between pure dynamo generated MF and shock wave compressed one

2. What we know about LSP? (Percy et al. 2016)

LSP ~ 8.1 +/- 1.3 times the excited pulsation period
No evidence for more than one LSP in each star
Multicolor photometry showed that LSP color variations are similar to those of pulsation P
The amplitudes vary by a factor of two on a timescale 20-30 LSP

Eventual mechanisms for LSP suggested:
-the turnover of giant convective cells
-oscillatory convective modes
-dusty cloud orbiting the red giant
- rotation modulation due to spots

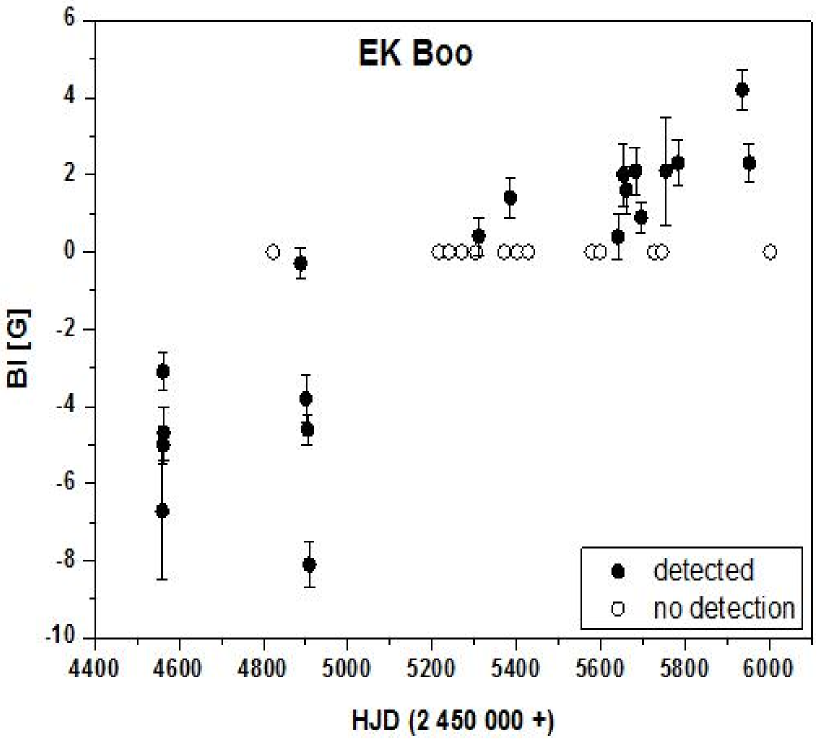
•What could be concluded:

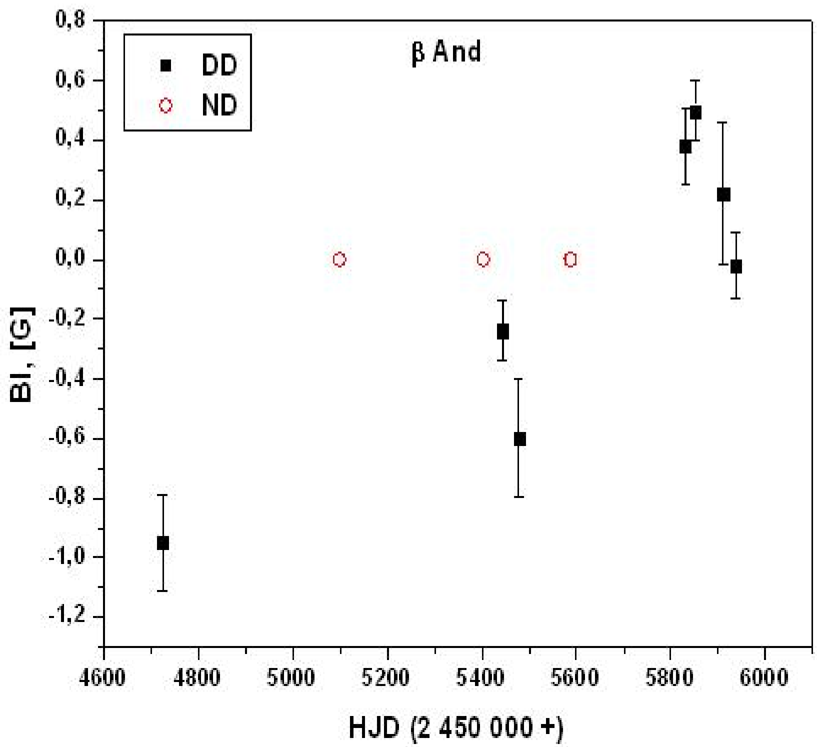
- In many cases Prot > LSP
- Color variations similar to those in the pulsation
- Sine shape variability from photometry

- No evidence for giant convective cells in magnetic M giants (contrary to the supergiant Betelgeuse, Auriere et al. 2016; Mathias et al. 2018, in press)
- RZ Ari not known as binary star
- **Conclusion:** LSP rather possible to be related to the pulsations than other reasons mentioned above

Do we observe an interplay between dynamo and pulsations in RZ Ari?

Long-term variability in other sample stars:





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Thank you for your attention!