# On the magnetic field variability in two fast rotating M giants

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# Introduction

In the past,  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).Recently, we obtained data with a high accuracy for magnetic fields in single M giants (Konstantinova-Antova et al. 2010;2013;2014).

Here we present the results of our long-term magnetic field study of 2 single M giants with fast rotation, RZ Ari and beta Peg.

# Our first sample 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. 2004). These stars were observed since 2008 till end of 2016, under different programs. Data for them are presented in the Table 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 –the star with fastest rotation and strongest MF in our sample

# Observations

The observations were performed at the 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. For each star, series of 8 to 16 spectra are done for one date. 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.

# RZ Ari = HD 18191:

Sp class:  M6 III

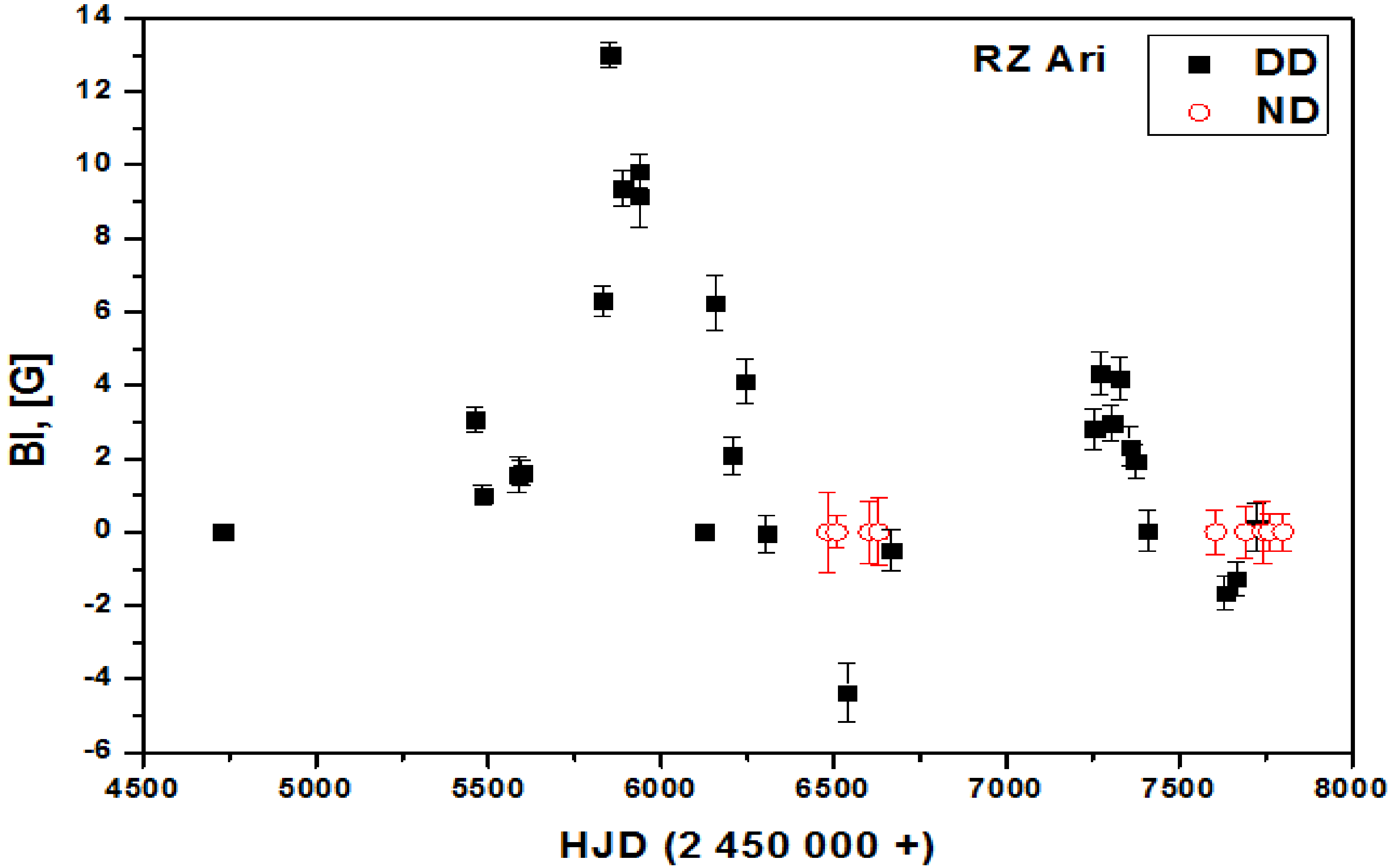
Teff=3450 K, log (L/Lsun) = 3.11

**Vsini = 9.6 km/s**

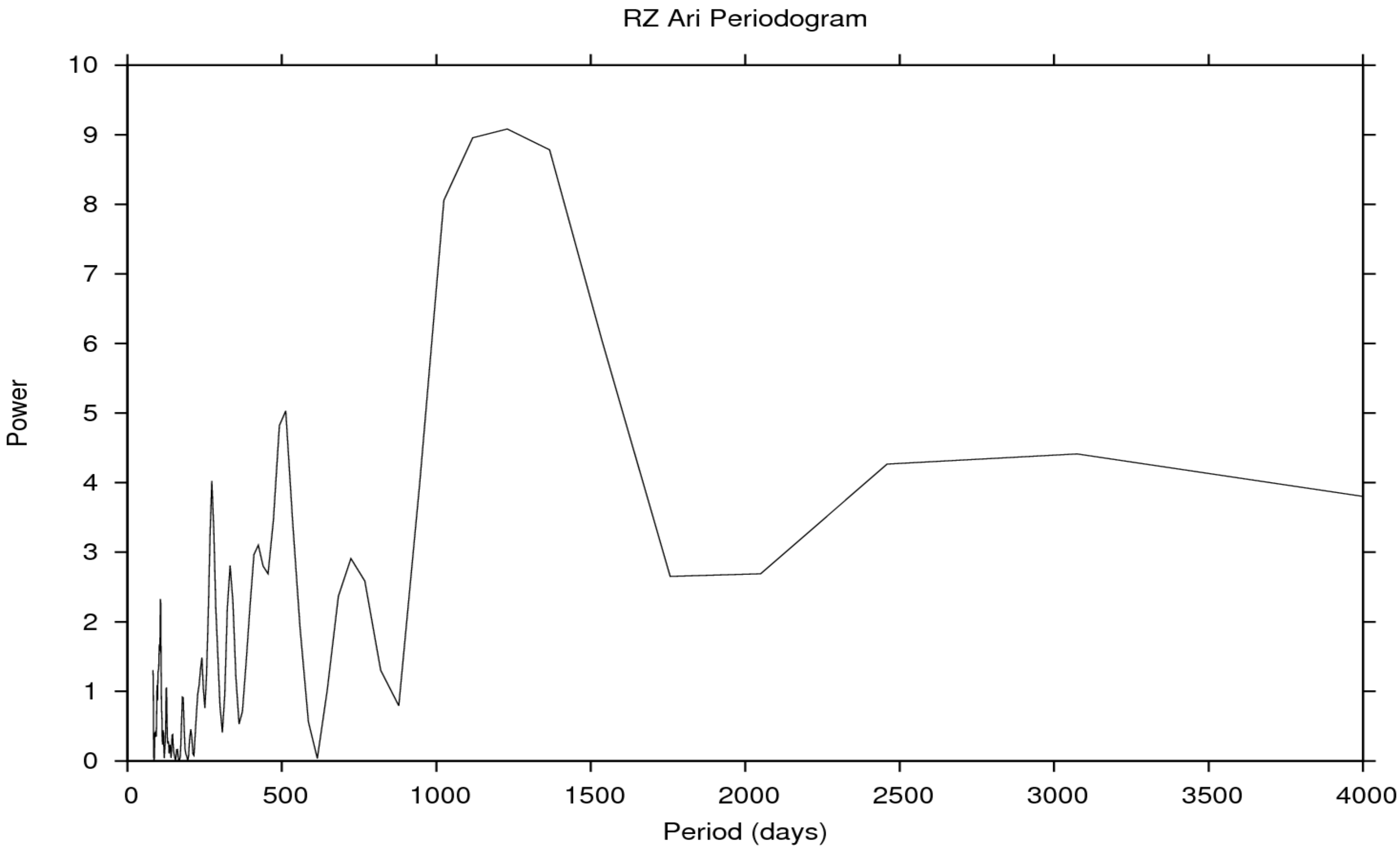
M ~ 2.2 Msun => either tip RBG or AGB

(Konstantinova-Antova et al. 2010)

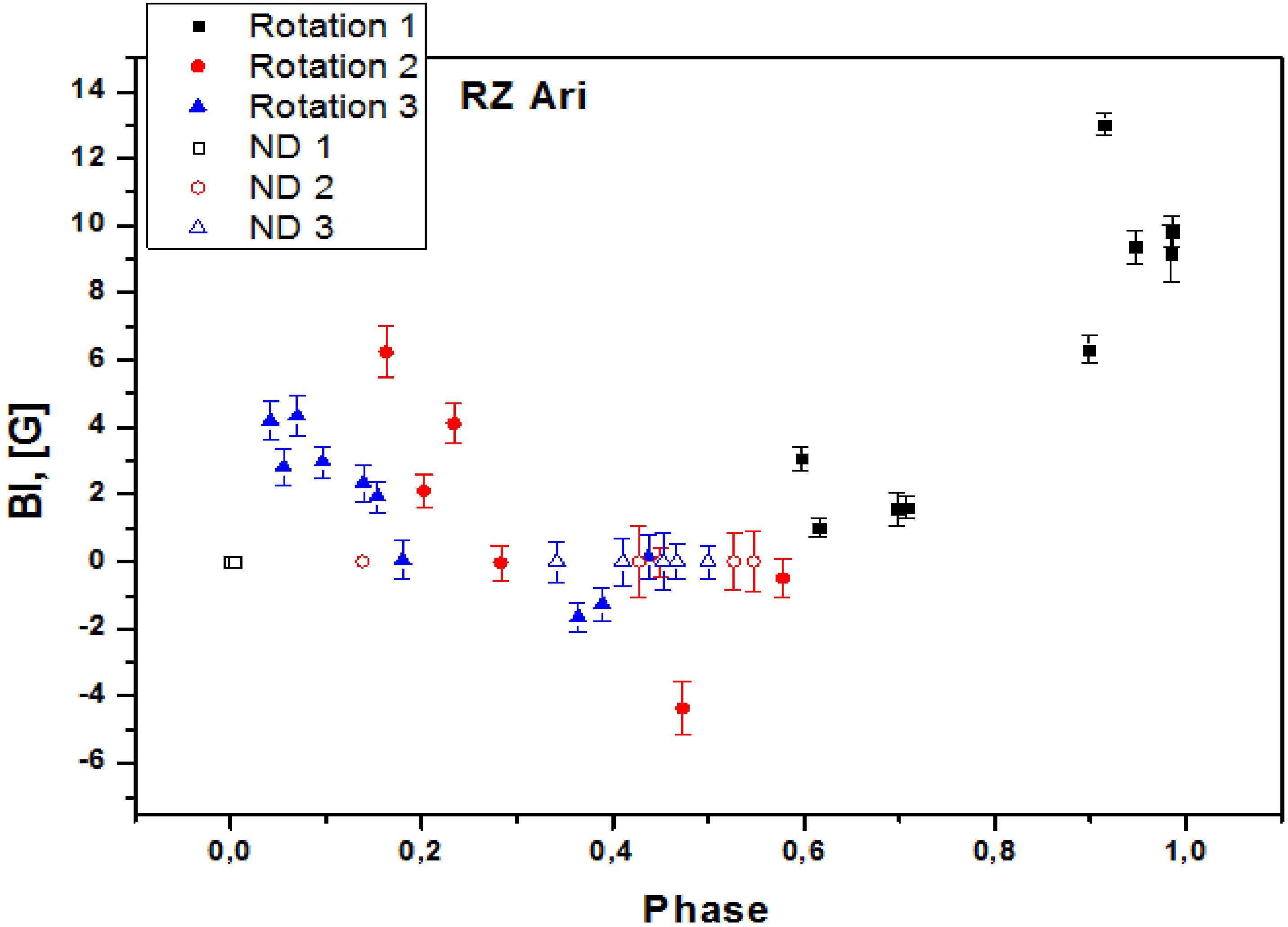
# RZ Ari – Bl variability
# Sept. 2008 – Feb. 2017



# RZ Ari – period: Lomb-Scargle 1229.9d, +11% -9%, fap 1.6%

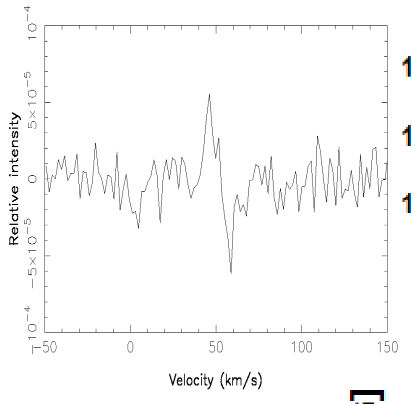


# RZ Ari – phased Bl variability:

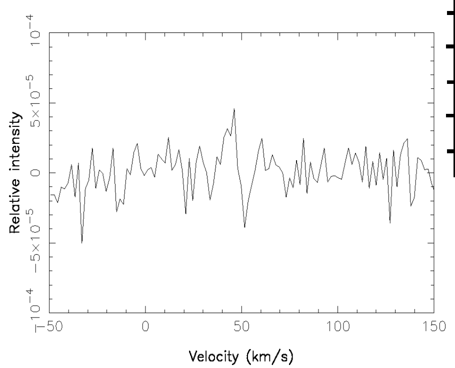


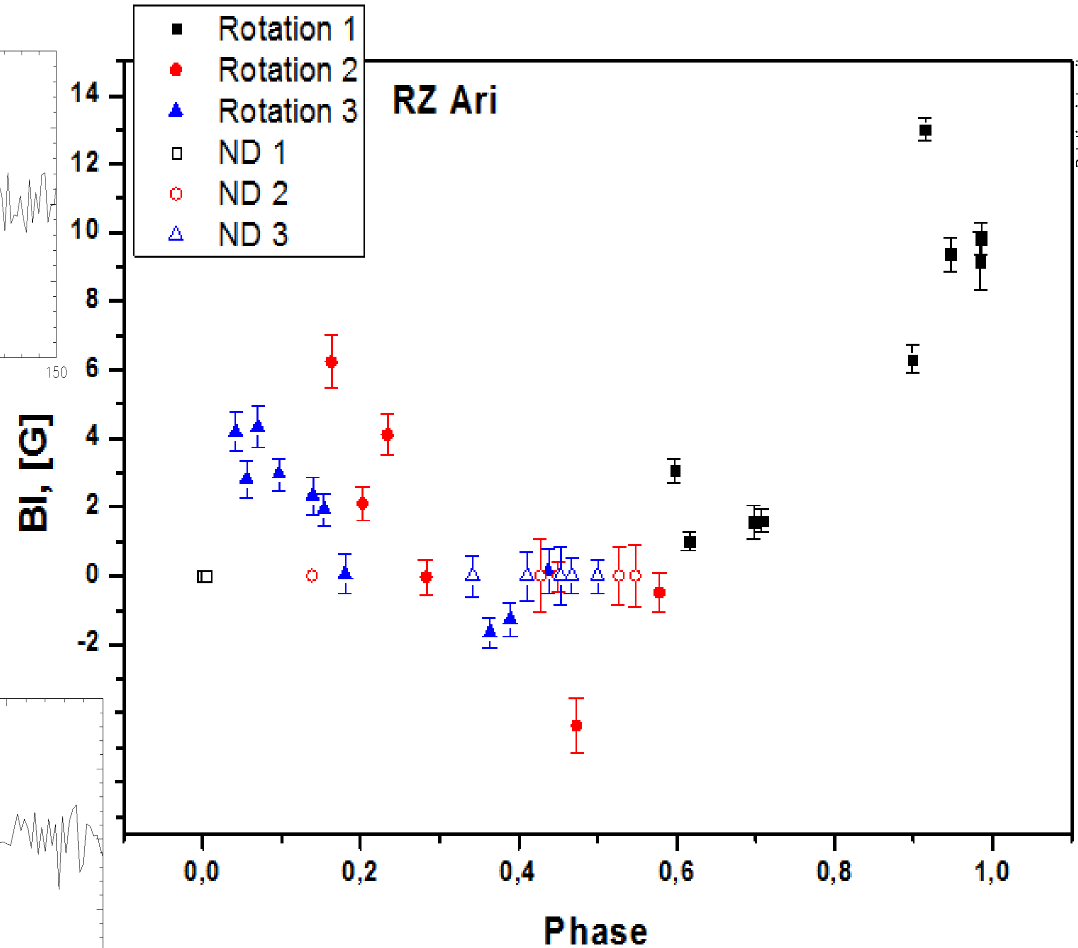
# RZ Ari – phased BI variability:

Phase=0.18

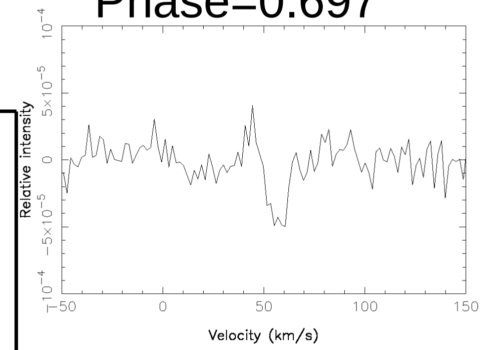



Phase=0.20

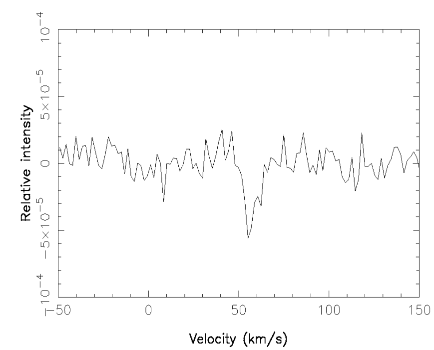



Phase=0.697




Phase= 0.707



# RZ Ari – additional data:

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

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

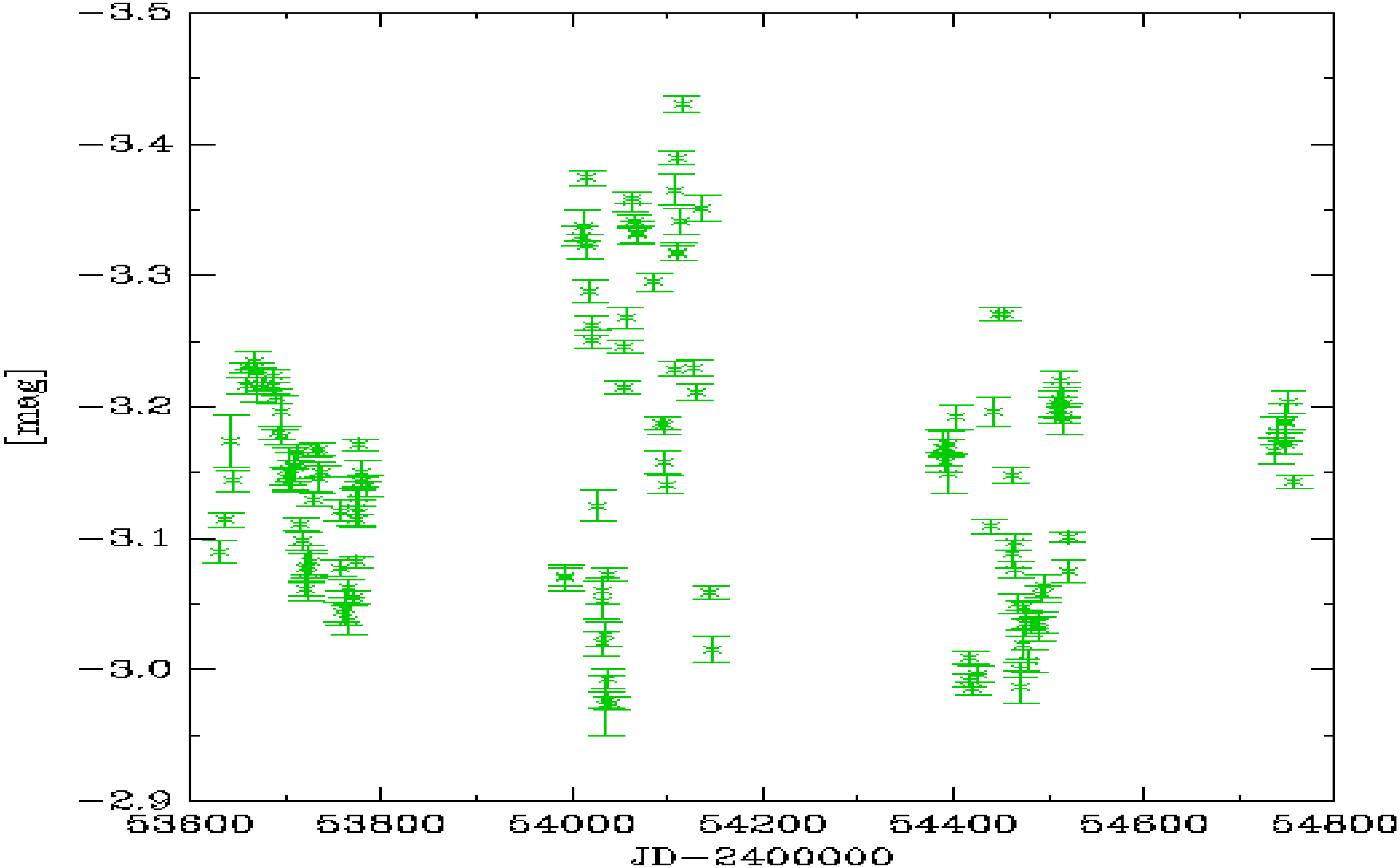
Angular diameter d – 0.01022 arcsec (Richichi et al.2006)

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

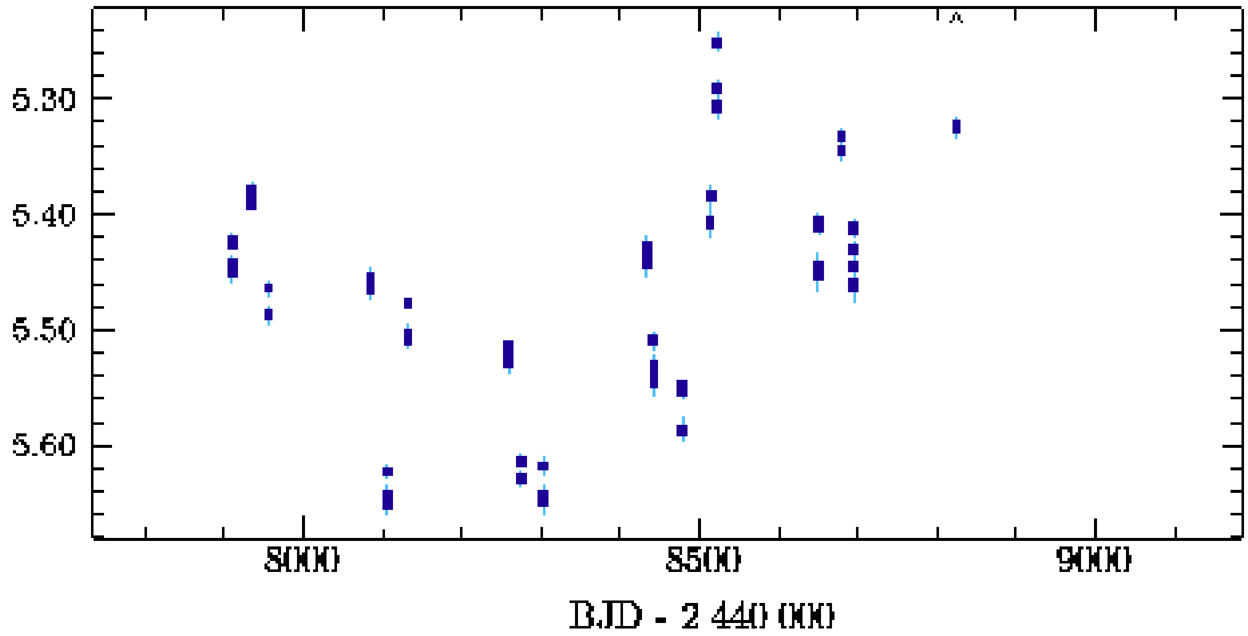
R*= tg (d/2) x r = 117.2 Rsun – consistent with AGB phase

# Rotation and pulsations?

## Hipparcos K-band lightcurve (Tabur et al. 2009)

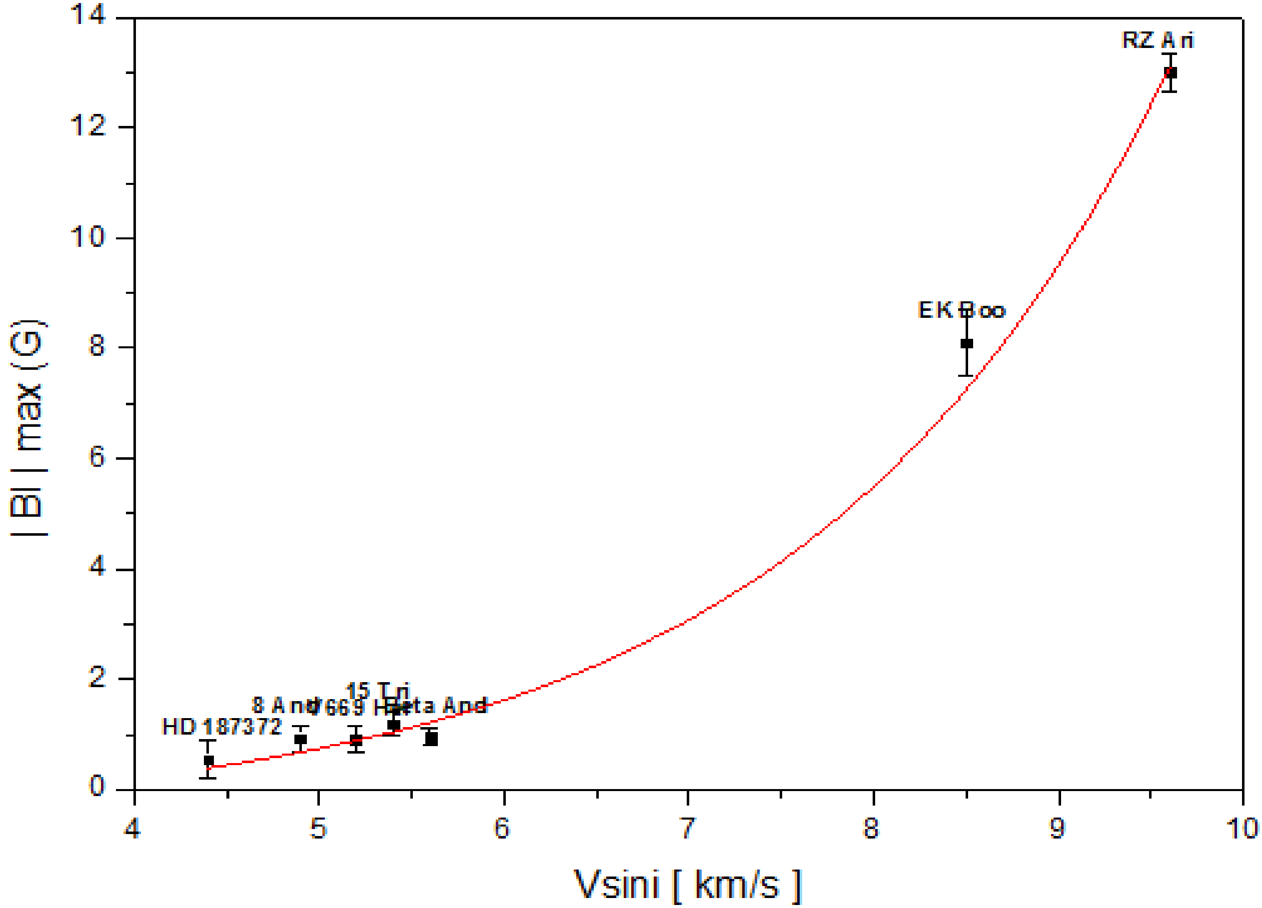


# Rotation and pulsations? Hipparcos database



# Rotation and pulsations?

## Konstantinova-Antova et al. 2013



# Beta Peg:

Sp class:  M2.5 II- III

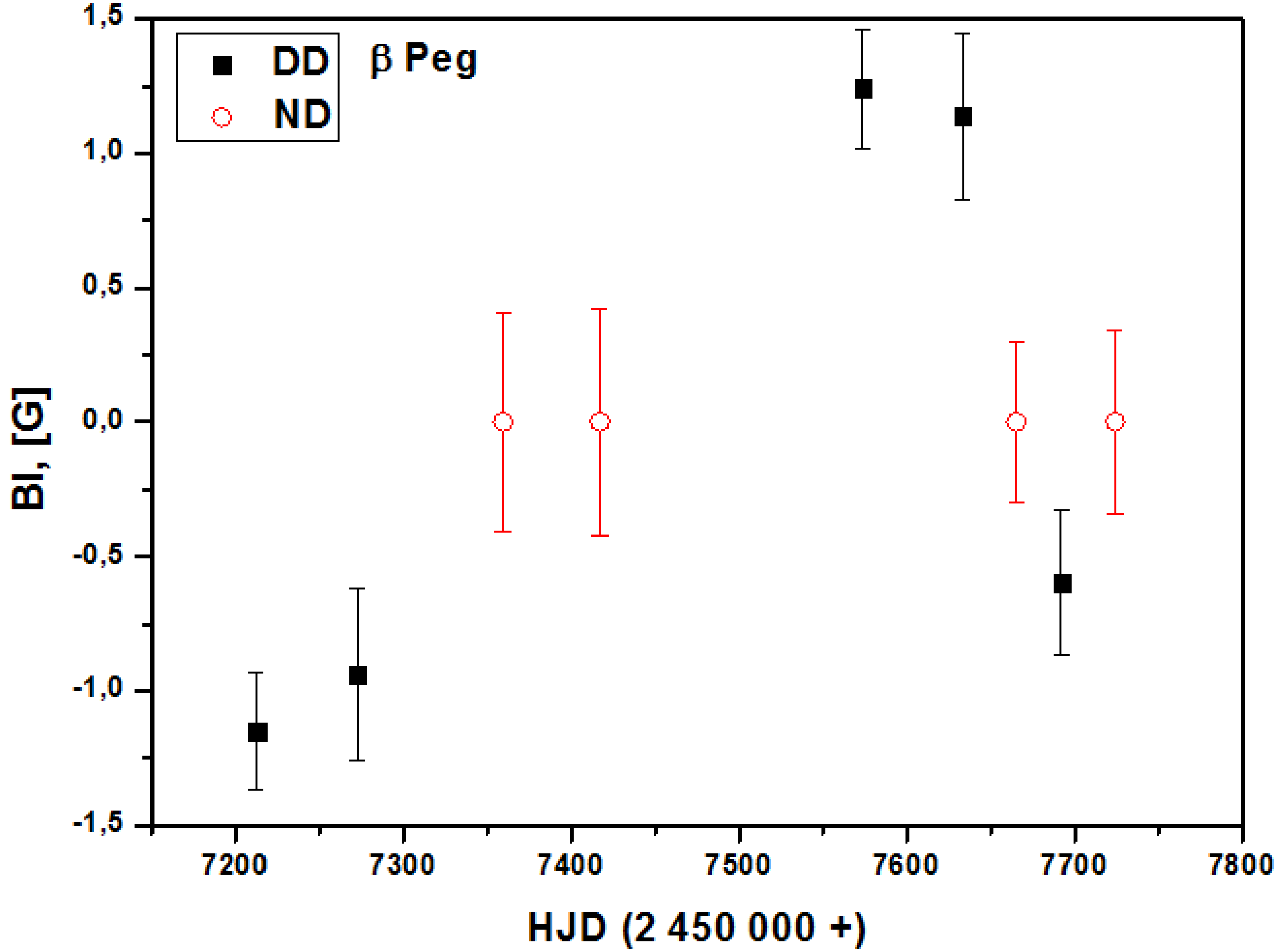
Teff=3860 K, log (L/Lsun) = 3.15

**Vsini = 7 km/s**

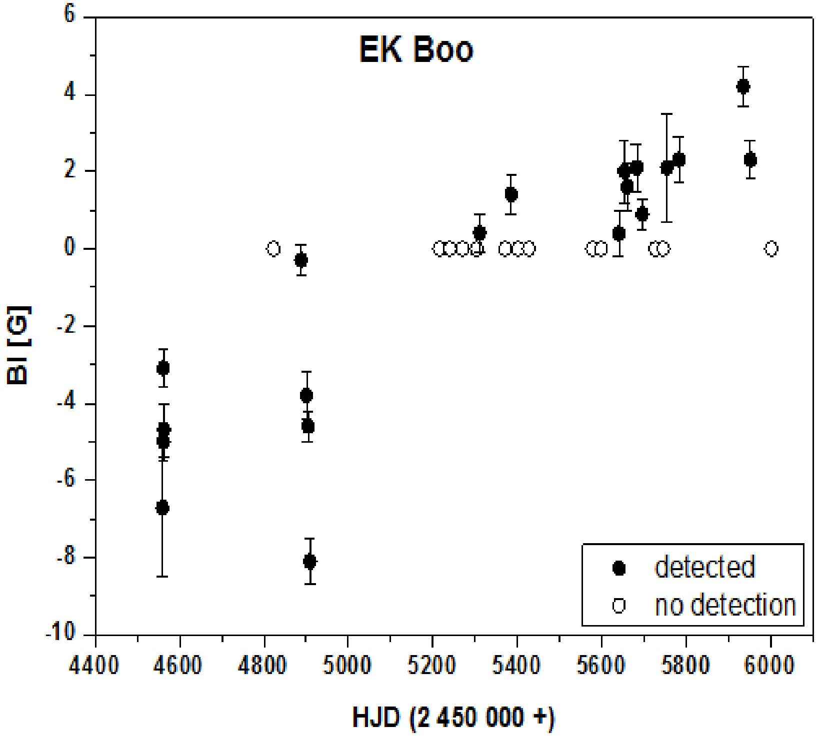
M ~ 4 Msun => AGB

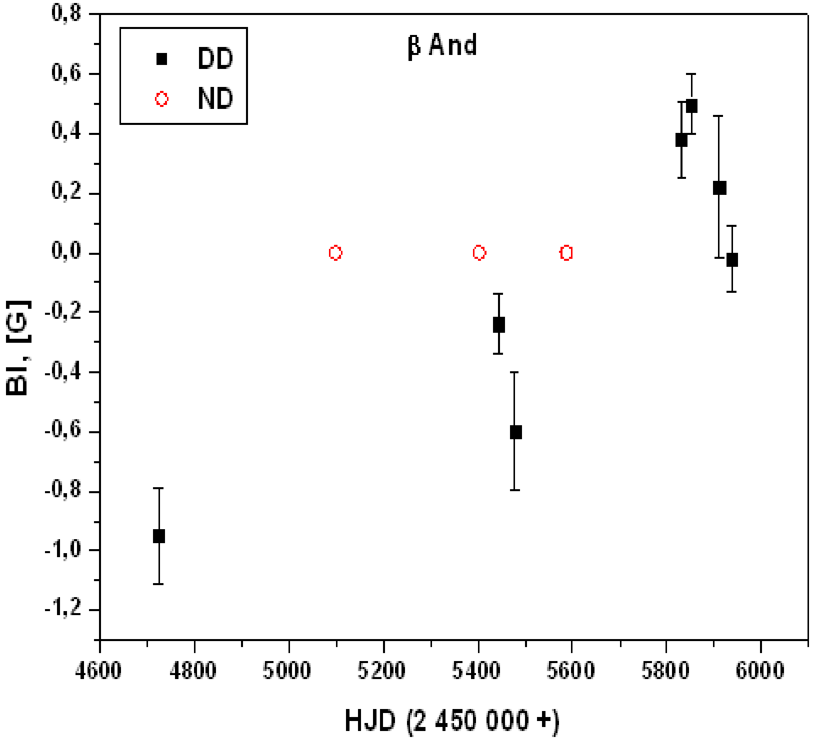
(Konstantinova-Antova et al. 2014)

# Beta Peg: July 2015 – Dec 2016



# Long-term variability in other sample stars:



# Dynamo operation and its origin

According to Charbonnel et al. (2017) α - ω dynamo could operate at certain stages after MS, including early AGB, due to the properties of the convective envelope. However, the fast rotation in our sample early AGB stars remains a puzzle. One possible explanation is the second dredge-up. Dredge-up begins when the nuclear fuel in the core is exhausted and the core begins to contract. In the same time, the envelope expands and cools. Convective mixing begins (Herwig, 2005). The core contraction leads to its fast rotation. It is possible during this phase, together with the chemicals, fast rotating material to be dredged-up. Another possibility for faster rotation is the planet engulfment during tip RGB and early AGB phases.

# Future prospects:

- ZDI for RZ Ari
- study on the interplay between magnetic field and pulsations;
- further quasi-simultaneous observations – spectropolarimetry + photometry desirable

Thank you for the attention!