HIGH-ACCURACY MAGNETIC FIELD MEASUREMENTS ON COOL GIANT β GEMINORUM

D.N. Baklanova, S.I. Plachinda

Crimean Astrophysical Observatory
Nauchny, Crimea 98409 Ukraine, *dilyara@crao.crimea.ua*

ABSTRACT. Pollux is a weakly-active yellow giant neighbor of the Sun with known regular surface magnetic field about 1 Gauss. We present new high-accuracy magnetic field measurements of β Gem which were obtained during 2010 at Crimean Astrophysical Observatory with 2.6-m telescope and Stokesmeter.

Key words: Stars: magnetic field; stars: individual: β Gem.

1. Introduction

Pollux (β *Geminorum*, HD 62509, HR 2990) is a single bright and well-studied star, classified as a K0 IIIb giant. The distance to Pollux was measured by Hipparcos and equals to 10.3 pc. Interferometric measurements have determined stellar diameter of $8.8 \pm 0.1\ R_{\odot}$ (Nordgren et al., 2001). Published parameters differ for different investigators. Values of effective temperature $T_{eff} = 4660 \div 4920$ K, a surface gravity $\log g = 2.52 \div 3.15$, metallicity $[Fe/H] = -0.07 \div 0.19$, and stellar mass $M_{\star} = 1.7 \div 2.3 M_{\odot}$. The radial velocity variations with a period of 554 days have been discovered for β Gem by Hatzes & Cochran (1993). The main hypothesis for these variations is that they due to a planetary companion with a mass of $2.9 M_{Jup}$. Subsequently Hatzes et al. (2006), Reffert at al. (2006) and Han et al. (2008) confirmed this explanation with a revised period in the range of 590–596 days. Aurière et al. (2009) reported the detection a weak magnetic field about 1 Gauss on the surface of Pollux changing with radial velocity's period of 589.64 days.

2. Observations

Spectropolarimetric observations of β Gem were carried out at the Crimean Astrophysical Observatory using coudé spectrograph of 2.6-meter Shajn telescope and Stokesmeter. Our data overlap interval of 9 nights from 25 February to 2 May 2010. 194 circular polarization spectra were collected with resolution $\sim$30000 and signal-to-noise ratio from 270 to 580.

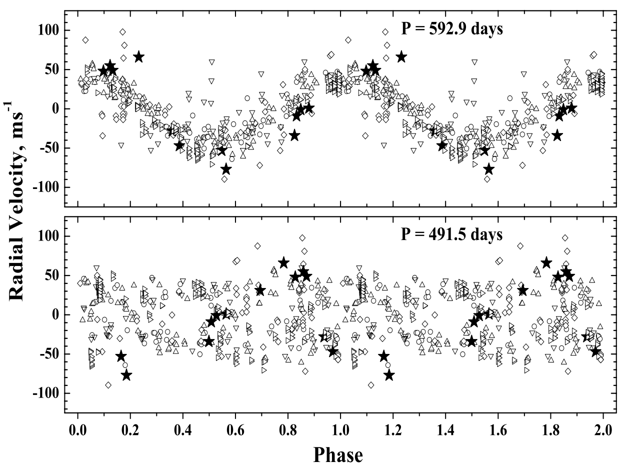

Figure 1: Radial velocities folded in phase with the orbital period of 592.9 days (upper panel) and the magnetic field's 491.5 days period (lower panel). The different symbols correspond to different source of radial velocity data. Diamonds are data from Larson et al. (1993), upside down triangles – from Hatzes and Cochran (1993), upward triangles – from Reffert et al. (2006), circles – from Hatzes et al. (2006), right triangles – from Han et al. (2008), and asterisks are from Aurière et al. (2009).

3. Results

We performed search for periodicity with the program Period04 (Lenz & Berger, 2004). Using all available radial velocity measurements from literature we re-determined the planetary companion rotation period, $P_{pl} = 592.9 \pm 0.6$ days. The upper frame in Fig. 1 shows the variations of radial velocity with orbital period of 592.9 days (phases were computed with ephemeris $P_{RVmax} = 2444158.8 + 592.9$ days). The lower frame in Fig. 1 shows the variation of radial velocity with magnetic field period. In the last case there is no periodic variations for all data, as it should have been, in spite of the radial velocities measurements from Aurière et al. (2009) which shown by asterisks.

From the analysis of power spectrum of magnetic

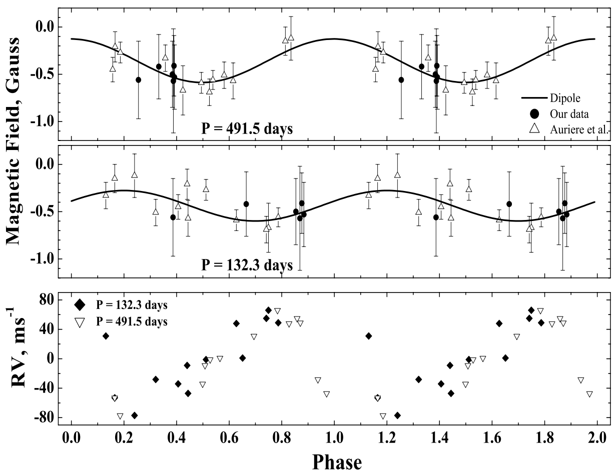

Figure 2: Longitudinal magnetic field folded in phase with the axial rotation period of 491.5 days (upper panel) and with period of 132.3 days (middle panel). Filled circles are our measurements of magnetic field; open triangles – data from Aurière et al.; dipole fit is shown by solid line. Bars are rms errors of measurement. Lower panel shows radial velocity's variations with the periods 132.3 days (filled diamonds) and 491.5 days (open triangles) using data from Aurière et al.

field measurements the axial rotation period of star, 491.5 days, was evaluated with 98% statistical significance (see Fig. 2, upper panel). For clear analysis we excluded lie out points. Using the Hipparcos photometry Hatzes et al. (2006) estimated a best fit period of 132.3 days the origin of which was not determined. The same period presents in power spectrum of the magnetic field measurements, but its statistical significance is only 77% (see Fig. 2, middle panel). In addition, because $2/(1/132^d.3 - 1/491^d.5) = 362.2$ days is very closed to year, we concluded that this period is artifact of frequency beating of star rotation period and year's season observations. The best fit to the magnetic field data in the case of the centered dipole gives the following results: the angle between spin axis and line of sight $i = 31° \pm 1°$ is in agreement with Hatzes' et al. (2006) $i = 28° \pm 3°$, and the angle between both the spin and dipole axes $\beta = 133°$.

In the lower panel of Fig. 2 the radial velocity from paper by Aurière et al. (2009) are phase-folded with two periods, 491.5 and 132.3 days. One can see the discrepancy between other authors' data and measurements by Aurière et al. (2009). The methods of RV measurements of both arrays of data differ from each other. In contrast to the nonpolarimetric data of other authors, the RV obtained by Aurière et al. (2009) were calculated using spectropolarimetric observations. The last RV data demonstrate the presence of both periods while the magnetic period, 491.5 days, is absent in data of other authors. We do not know the nature of such discrepancy between RV data from Aurière et al. (2009) and others authors.

In Fig. 3 all points of the magnetic field measurements are presented. We suppose that four lie out points of the curve fitting are the result of the active regions emergence on the stellar surface as it was discovered for solar-like star 61 Cyg A (Plachinda, 2004). Additional data, which will require further observations, are needed in order to confirm this result.

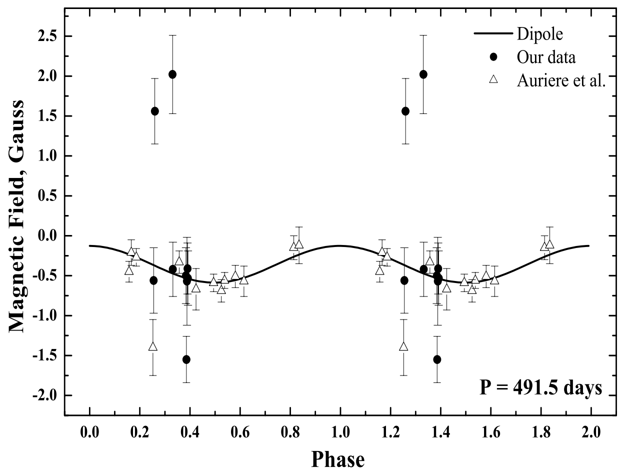

Figure 3: Magnetic field measurements folded in phase with the axial rotation period of 491.5 days. All points of the magnetic field measurements are presented. Filled circles are our measurements of magnetic field; open triangles – data from Aurière et al.; dipole fit is shown by solid line.

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