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Doppler imaging of the active star PW And

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Abstract. We present spot activity of the K2V pre-main-sequence star PW And based on the high-resolution spectroscopic data obtained at Xinglong station and BOAO in 2005 November and December. Using the Least-Squares Deconvolution method, we have derived time series of composite profiles of PW And with high signal to noise ratio. These have been used to reconstruct its starspot pattern via the Doppler imaging method. The result shows that intermediate to high-latitude spots are the dominant features and weak low-latitude spots also appear. Comparing Doppler images from two data subsets, it can be found that almost no difference between two images exists except the small position evolution of weak low-latitude spots, which suggests that the intermediate to high-latitude spots have longer lifetimes than one month, and the low-latitude spots have shorter lifetimes.

Keywords. stars: late-type, stars: activity, stars: spots

1. Introduction

PW And (HD1405) is one member of nearby AB Dor moving group (Montes *et al.* 2001b, Zuckerman & Song 2004). It is a young pre-main-sequence K2V dwarf with a large rotation velocity vsini=22-24km/s (Lopez-Santiago *et al.* 2003, Strassmeier & Rice 2006). Previous results show that PW And is an active star with starspots and chromospheric emission (Bidelman 1985, Hooten & Hall 1990, Montes *et al.* 2001a, Lopez-Santiago *et al.* 2003, Strassmeier & Rice 2006).

2. Observations and data reduction

PW And was observed at Xinglong station of National Astronomical Observatories, China (NAOC) on 2005 November 18-24 and December 17-22 using the 2.16m telescope and Coudé echelle spectrograph with a 1k×1k CCD detector (Zhao & Li 2001), and Bohyunsan Optical Astronomy Observatory, Korea (BOAO) on 2005 December 08-11 using the 1.8m telescope and BOES spectrograph with a 2k×4k CCD detector (Kim *et al.* 2002, Kim *et al.* 2007). The spectral resolution is about 36000 for Xinglong observations and about 48000 for BOAO one.

The observed data are reduced using IRAF package following standard procedure, including bias subtraction, flat fielding, background subtraction, cosmic ray removal, optimal extraction, wavelength calibration and continuum fitting.

3. Image reconstruction

In order to check whether the spot pattern evolves during our observing period spanned just more than one month, we separate the all data to two data subsets to do Doppler imaging respectively. Data subset 1 is corresponding to the observations made on Nov.18-24 (Xinglong) and Dec. 8-11 (BOAO), 2005, data subset 2 to the observations on Dec.8-11 (BOAO) and Dec.17-22 (Xinglong), 2005. To obtain time series of line profiles with the highest signal to noise ratios from the data for Doppler imaging purpose, we employ the Least-Squares Deconvolution (LSD) method (Donati *et al.* 1997) to combine the profile information from all the observed photospheric lines in each observed spectrum.

We use the single star mode of our Doppler imaging code DoTS (Collier Cameron 1997) to reconstruct the spot pattern of PW And based on the above LSD profiles. The resulting Doppler images based on two data subsets are shown in Fig. 1 where the mean spot filling vs. latitude is also displayed.

4. Discussion and conclusions

In Fig. 1, it can be seen that the predominant features of Doppler images of PW And in our observing season are intermediate to high-latitude spots, which are obviously different from the results derived by Strassmeier & Rice (2006), which show no spots appeared above the latitude 40°.

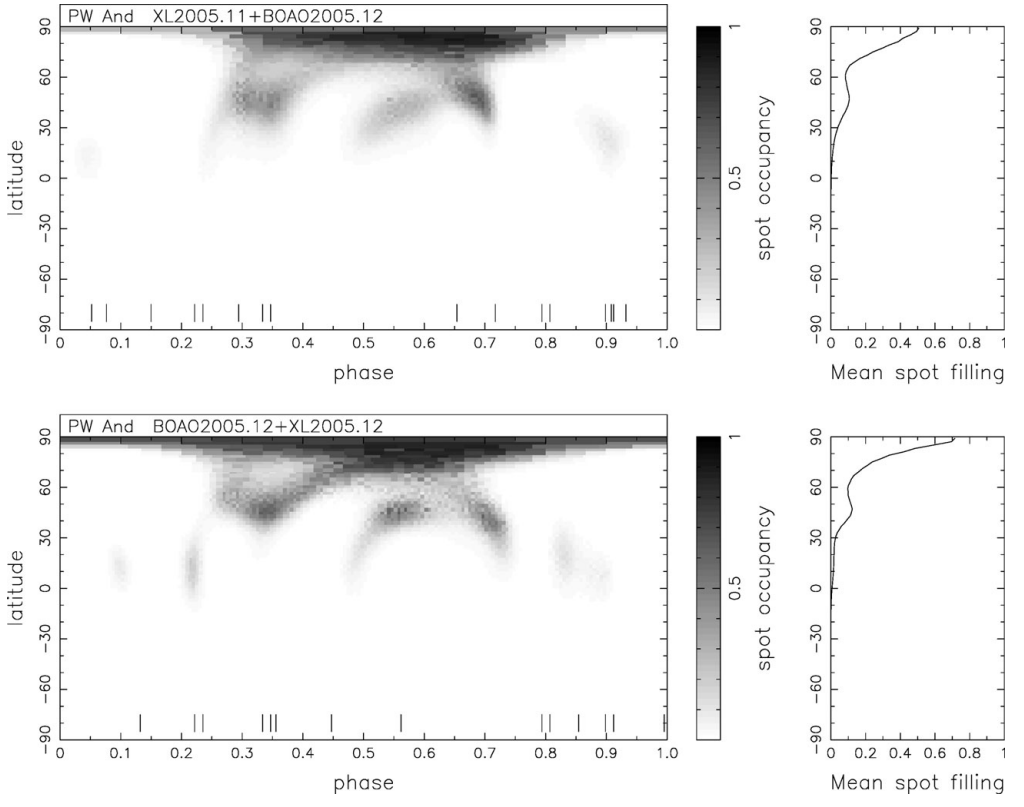

Figure 1. Doppler images of PW And for two data subsets. The upper image is for the data subset 1 and the lower one for the data subset 2.

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From the Doppler images in Fig. 1, it is clear that two spot patterns are almost the same as each other except small low-latitude spots. This indicates that the main structure of spot pattern is stable during one month time scale. However, the low-latitude spots have some changes either in position or in intensity. Such a result implies that the low-latitude spots seem to have shorter lifetimes than the intermediate to high-latitude spots, like most of other magnetic active stars.

Hooten & Hall (1990) obtained four groups of photometric data, and found the second dataset spanned more than 5 months gave a large scatter when searching the period although it contains the largest number of data points, whereas the fourth dataset spanned less than one month gave a small scatter for the period obtained. This suggests that the spot pattern is stable for short duration, and changes for long time interval.

From the observations collected in Aug. 2004, Strassmeier & Rice (2006) derived a spot pattern similar to our Sun, in which the six main cool spots concentrate below latitude 40°. From new observations made in Nov. and Dec. 2005, we get a obviously different spot pattern with the main spots distributed from latitude 41° to 83°. Such a large difference suggests that the lifetime of main spot structure cannot last more than one year.

These information suggests that the spot pattern of PW And should change largely during its one activity cycle, like another active single star LQ Hya with the same spectral type (K2V) and similar rotational velocity, whose Doppler imaging results show that sometimes the low-latitude spots were predominant, and the obvious polar spots appeared in other times (Donati 1999, Donati *et al.* 2003, kovari *et al.* 2004).

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