PRELIMINARY RESULTS OF DOPPLER IMAGING ANALYSIS OF roAp STAR α Cir

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ABSTRACT. Based on high-resolution spectra, we investigate the abundance distribution of chromium and silicon on the surface of α Cir using Doppler Imaging technique. Results of our analysis show the presence of chromium and silicon spots on the surface of α Cir as well as large gradients of the abundances of these elements.

Key words: Stars: Alpha Circini; methods:Doppler imaging mapping

1. Introduction

α Cir(HD 128898; HR 5463) is one of the brightest rapidly oscillating Ap (roAp) stars. Despite of the fact that this is one of the best studied roAp stars showing vertical stratification of several chemical elements (see Kochukhov et al. 2009), Doppler Imaging (DI) analysis of this star was not carried out so far. In this paper we fill in this gap in the study of α Cip and represent preliminary results of DI mapping based on chromium and silicon lines. In Sect.2, we shortly describe the observational material that we have at our disposal as well as the data reduction procedure. Sect.3 is devoted to the description of DI technique while the results are presented in Sect.4. Finally, Sect.5 gives the summary of our study.

2. Observations and data reduction

We have obtained 5 high-resolution spectra with the UCLES coude echelle spectrograph installed at the 3.9-m Anglo-Australian Telescope (AAT) and 6 high-resolution spectra with the UVES echelle spectrograph installed at the 8.2-m Very Large Telescope (VLT). The spectra cover wavelength range from 6115 Å to 6155 Å. Although the UVES spectra have been reduced with the standard pipeline installed at the telescope, we had to reduce the spectra from UCLES. For this aim, an automatic data reduction procedure have been developed.

Table 1: Journal of observations. HJD is the heliocentric Julian Date, ϕ is the corresponding rotational phase.

Seq.	Source	HJD	ϕ
1	UCLES	2453510.844	0.812
2	UCLES	2453511.851	0.037
3	UCLES	2453512.891	0.269
4	UCLES	2453513.902	0.495
5	UCLES	2453514.892	0.716
6	UVES	2451945.894	0.430
7	UVES	2451946.895	0.654
8	UVES	2451947.889	0.876
9	UVES	2451953.895	0.217
10	UVES	2451954.893	0.440
11	UVES	2451955.900	0.665

Table 1 gives the journal of observations. Rotational phases have been computed in accordance to the Julian Dates calculated for all spectra as follows:

$$HJD = 2453937.2086 + 4.4790 * E. \quad (1)$$

3. Doppler Imaging technique

Stellar surface inhomogeneities, such as a nonuniform distribution of temperature or chemical composition, lead to characteristic distortions in the profiles of Doppler broadened stellar spectral lines. In the course of stellar rotation these distortions will move across the line profiles due to the changes in visibility and Doppler shifts of individual structures at the stellar surface.

The Doppler imaging (DI) technique utilizes the information contained in the rotational modulation of the absorption line profiles and reconstructs features at the surfaces of stars by inverting a time series of high-resolution spectra into a map of the stellar surface.

4. Results

We started with the selection of the spectral line profiles showing variability with rotational phase. For

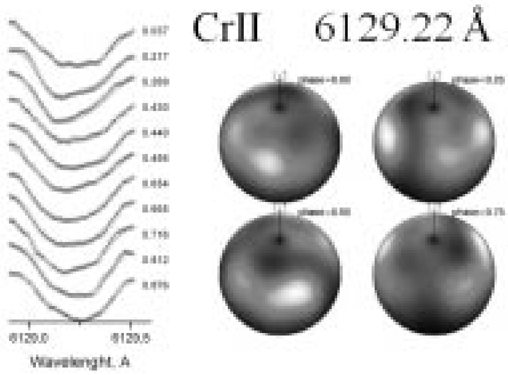

Figure 1: Stellar surface abundance map for Cr in spherical projection obtained based on Cr II 6129.22 Å line. Comparison between observed (crosses) and computed (solid lines) spectra are given to the left. Scale is in dex.

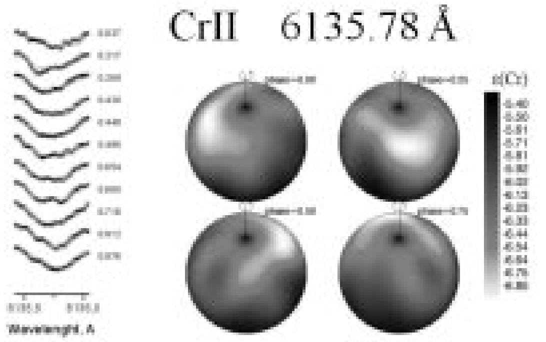

Figure 2: Same as Fig. 1 but for Cr II 6135.78 Å line.

our analysis, we have selected three Cr II lines (Cr II 6129.22 Å, Cr II 6135.78 Å, Cr II 6147.15 Å) and one Si I line (Si I 6125.02 Å).

For the DI analysis, we used the INVERS8 program (Piskunov & Rice 1993) which uses Tikhonov regularization delivering results in the sense of the smoothest map in terms of stellar surface abundances that is possible to fit the observations at a certain level. The program uses pre-calculated tables of intrinsic line profiles which have been computed with the SynthV code (Tsymbal 1996) using the LLmodels atmosphere models (Shulyak et al. 2004). Atomic line lists were taken from the VALD database (Kupka et al. 2000).

Figs. 1–3 show the abundance distribution for Cr in spherical projection. Comparison between observed (crosses) and computed (solid lines) line profiles are shown to the left. The bright spots of lower chromium abundance are clearly seen on the surface of the star and the observed line profiles are well fitted. The rotational velocity of 12.5 km s^{-1} and the inclination angle of the rotation axis to the line of sight of 35° were adopted in the model.

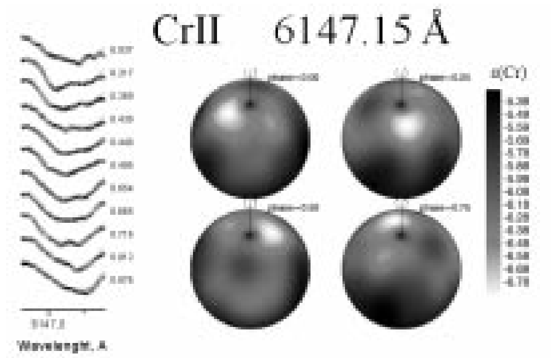

Figure 3: Same as Fig. 1 but for Cr II 6147.15 Å line.

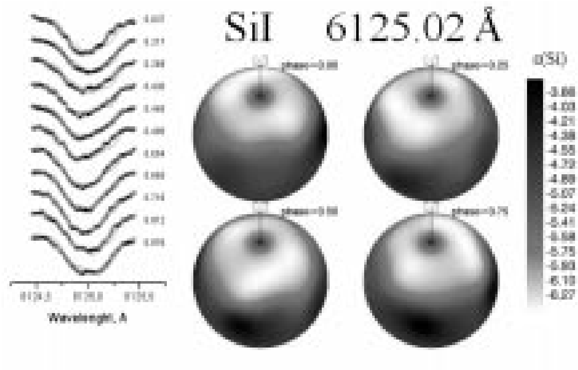

Figure 4: Same as Fig. 1 but for Si I 6125.02 Å line.

As shown in Fig.4, the abundance distribution of Si on the surface of α Cir is characterized by a large spot of lower abundance located at the rotational pole of the star. Both, Cr and Si show large gradients of the abundances of about 2.4 dex.

5. Discussion

Based on high-resolution spectra obtained with two different instruments, we have carried out Doppler Imaging analysis of roAp star α Cir. Despite of the small number of spectra that we had at our disposal, we could show that both Cr and Si are inhomogeneously distributed on the star's surface showing large gradients of about 2.4 dex.

In future, we plan to carry out a more detailed study of α Cir based on extended spectroscopic observations.

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