ZEEMAN DOPPLER IMAGING OF TWO HOT STARS

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Abstract. Magnetic fields are known to exist in about 10% of hot stars on the main sequence. High-resolution data and the increase in computing power have enabled the development of new methods to map and characterize stars. Zeeman-Doppler-Imaging (ZDI) is one of them and it allows one to determine the magnetic topology at the stellar surface. Through a modelling of the intensity and polarized line profiles, ZDI aims at reconstructing the vectorial magnetic field at the stellar surface. We have acquired high-resolution spectropolarimetric observations for two hot stars: the Bp star V352 Peg and the early-B star i Car. Through a Least-Square Deconvolution, we extracted the intensity and mean Zeeman signature of thousands of spectral lines. We have established the presence of a magnetic field in both stars. Using a python ZDI code, we mapped and characterized their magnetic field, revealing two completely different configurations. While V352 Peg exhibits a strong, dipolar field with a polar field strength of ~ 9 kG, i Car shows a weaker field strength and a more complex, significantly toroidal, field topology.

Keywords: stars: chemically peculiar – stars: magnetic field – stars: individual: V352 Peg, i Car – techniques: spectropolarimetry

1 V352 Peg and i Car

V352 Peg is an α^2 CVn star, first detected as a photometrically variable star by the Hipparcos mission (Perryman et al. 1997). With an effective temperature of 11850 ± 180 K and a gravity of $\log g = 4.35$ (Stassun et al. 2019), V352 Peg is a hot star in the early main sequence stage. Its period is found to be $P_{\rm rot} = 2.63654 \pm 0.00008$ days (Fréour et al. 2021).

i Car has an effective temperature and gravity of 18900 ± 500K and $\log g = 3.94$ (Levenhagen & Leister 2006), being thus hotter and more evolved than V352 Peg. Its rotation period of $P_{\rm rot} = 22.24$ days (Neiner et al. 2021) is much longer than that of V352 Peg.

We have acquired 17 spectropolarimetric observations of V352 Peg between 2018 and 2019 and one archival observation from 2011 with the ESPaDOnS spectropolarimeter at CFHT, and 34 spectropolarimetric observations of i Car in 2015 obtained with HARPSpol at ESO.

2 Zeeman-Doppler Imaging (ZDI)

The ZDI method aims to reconstruct the vectorial magnetic field at the stellar surface by fitting Stokes profiles I and V obtained from spectropolarimetric observations. Using the code by Folsom et al. (2018), we fit the Stokes I and V profiles of the two stars and studied their magnetic configurations.

The Stokes I profiles of V352 Peg vary with the rotation phase of the star (Fig. 1). This is not the case for i Car. This variability is due to an inhomogeneous distribution of chemical elements at the stellar surface, typical of chemically peculiar stars. A clear magnetic signature is visible in the Stokes V profiles of both stars, showing rotational modulation due to the misalignment between the stellar rotation and magnetic axes as described by the oblique rotator model.

Using ZDI, we could characterise the magnetic configuration of V352 Peg and i Car as well as the distribution of the magnetic energies. We estimated the inclination angle and the obliquity angle of V352 Peg to be $i =$

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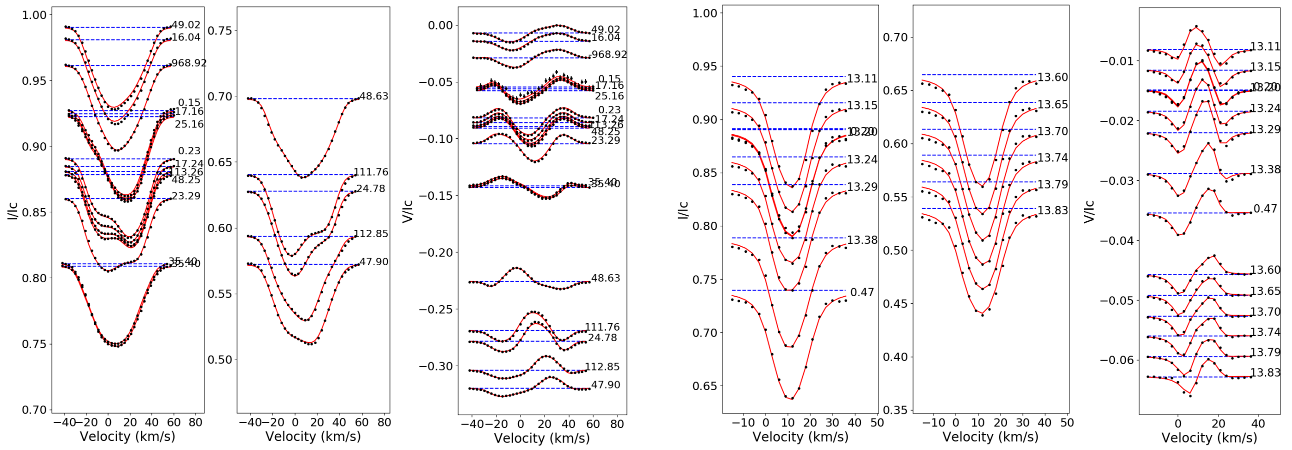

Fig. 1. Comparison between observed (black dots) and simulated (red lines) Stokes I (left 2 panels) and V (right) profiles of V352 Peg (left figure) and i Car (right figure). Taken from Fréour et al. (2021) and Neiner et al. (2021).

$62.5^{\circ}{}^{+4.0}_{-3.5}$ and $\beta = 100.5 \pm 4.0^{\circ}$. For i Car, we find $i = 54.2^{\circ}{}^{+3.6}_{-3.2}$ and $\beta = 137.5^{\circ}{}^{+4.2}_{-3.2}$. V352 Peg has a polar magnetic field strength of about 9 kG while it is only around 1 kG for i Car.

We also find differences in the distribution of the magnetic energies. While the magnetic field of V352 Peg is mainly poloidal (98.7%) and dipolar (91.6% of the poloidal field), the toroidal component of the magnetic field of i Car is dominant (71.5%) and the dipole percentage lower (76.3% of the toroidal field). The quadrupolar and octupolar components of the poloidal field (respectively 11.7% and 13.5%) of i Car contribute more to the total magnetic energy than in the case of V352 Peg (respectively 1.6% and 4.7%).

3 Conclusions

The results of our ZDI analysis show two clearly different magnetic configurations, highlighting the differences between the magnetic topology of a chemically-peculiar main-sequence star (V352 Peg) and a chemically-normal weaker-field star (i Car).

Based on observations obtained at the Canada-France-Hawaii Telescope (CFHT) which is operated by the National Research Council(NRC) of Canada, the Institut National des Sciences de l'Univers of the Centre National de la Recherche Scientifique (CNRS) of France, and the University of Hawaii. Based on observations obtained at the European Southern Observatory (ESO), Chile.

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