Stars and their variability observed from space
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MAGNETIC FIELD MEASUREMENTS OF KEPLER AP/CP2 STARS

I. I. Romanyuk[1], Z. Mikulášek[2], S. Hümmerich[3], I. Yakunin[1], A. Moiseeva[1], J. Janík[2], K. Bernhard[3], J. Krtička[2], E. Paunzen[2], M. Jagelka[2], M. Zejda[2], and M. Vaňko[4]

Abstract. We present first results of the ongoing search for magnetic fields in eight Ap/CP2 stars and one candidate in the Kepler field using the spectropolarimeter of the 6-meter SAO reflector in Russia. Five stars (KIC 4180396, KIC 5264818, KIC 5473826, KIC 6065699, and KIC 8324268) were found to harbor a strong magnetic field. Very likely, KIC 6864569 is also a magnetic star, but more observations are needed. The status of KIC 8161798 and KIC 10324412 remains as yet unclear; no significant field was detected for the CP2 star candidate KIC 6278403. The resulting sample will facilitate research on the connection between magnetic field topologies and surface chemical structures in mCP stars.

Keywords: Chemically peculiar stars, magnetic field

1 Introduction

We searched for magnetic fields in eight Ap/CP2 stars and one candidate in the Kepler field. These upper main-sequence objects are characterized by peculiar photospheric abundances thought to be produced by selective processes (radiative levitation and gravitational settling) operating in their calm radiative atmospheres. CP2 stars belong to the magnetic chemically peculiar (mCP) stars, which possess strong global magnetic fields, possibly of fossil origin. In many mCP stars, the overabundant chemical elements are concentrated into chemical spots or patches. These objects display strictly periodic light, spectrum and magnetic variations, which can be well described by a rotating star model with a non-axial stable magnetic field and persistent chemical structures. However, the physical connection between the magnetic field topology and the structure of the chemical surface inhomogeneities is not yet understood or well explored. Furthermore, the recent study by Jagelka et al. (2019) indicates that - in contrast to what is generally assumed - the distribution of the chemical spots does not follow the magnetic field topology. Clearly, further investigations into this topic are necessary.

Our intended project "Probing the role of the magnetic fields in the physics of chemically peculiar stars using BTA-6 spectropolarimetry" aims to assess and better comprehend the role of the global magnetic field in the process of the formation and sustaining of the chemical surface abundance inhomogeneities of mCP stars by using high-quality BTA-6 spectropolarimetry and ultra-precise photometric data from the Kepler and TESS satellites. These data will offer unique and detailed information about chemical structures and magnetic field geometry for a representative sample of mCP stars. As a pilot study, we have observed eight Ap/CP2 stars and one candidate in the Kepler field, which were selected from the list of Hümmerich et al. (2018) and unpublished observations. Our data constitute the first spectropolarimetric measurements of these objects.

2 Magnetic fields measurements

In April and May 2019, we obtained a total of 31 spectra for all nine objects using the Zeeman analyzer. Strong magnetic fields were found in five stars: KIC 4180396 = HD 225728 (2 spectrograms), KIC 5264818 = HD 180374 (4), KIC 5473826 = HD 226339 (2), KIC 6065699 = HD 188101 (5), and KIC 8324268 = HD 189160 (5). Very likely, KIC 6864569 = BD+42 3356 (2) is also a magnetic star, but more observations are needed.

The status of KIC 8161798 = BD+43 3223 (only one spectrum), and KIC 10324412 = HD 176436 (5) remains as yet unclear. No significant magnetic field (amplitude 40 ± 140 G) has been detected in the only CP2 star candidate of the sample, KIC 6278403 = HD 181436 (5).

[1] Special Astrophysical Observatory of the RAS, Nizhnii Arkhyz, Karachai-Cherkessian Republic, 369167, Russia
[2] Department of Theoretical Physics and Astrophysics, Masaryk University, Kotlářská 2, 61 387 Brno, Czech Republic
[3] Bundesdeutsche Arbeitsgemeinschaft für Veränderliche Sterne e.V. (BAV), D-12169 Berlin, Germany
[4] Astronomical Institute of the Slovac Academy of Science, Tatranská Lomnica, Slovac Republic

Two of the CP2 stars were observed so well that we can discuss the relationship between their magnetic and light phase curves.

HD 180374 is an A0 IV Si star (Gray et al. 2016), displaying a double wave light curve with effective amplitude of 25.8 mmag and period $P = 1.905\,050\,059(5)$ d (Hümmerich et al. 2018), while the magnetic field dependence $\langle B_z \rangle$ is a pure cosine wave with an amplitude of 4.0 kG and extrema that coincide in phase with the light maxima. Thus, regions of increased silicon content can be expected to be present in the area of the magnetic poles. However, this speculation has yet to be verified spectroscopically.

HD 189160 is an A0 V SiCr star, displaying a single, slightly asymmetric light curve with effective amplitude of 27.1 mmag and period $P = 2.009\,120\,16(7)$ d (Hümmerich et al. 2018), while the magnetic field curve $\langle B_z \rangle$ is also a cosine wave with an amplitude of 1.25 kG, with a maximum that coincides in phase with the light maximum.

However, both stars show a visible link between the distribution of spots with increased content of optically active chemical elements (such as silicon or iron) and the dipole geometry of the magnetic field found. This, however, contradicts our recent finding (Jagelka et al. 2019) that the analysis of CP2 star light curves obtained by ASAS 3 (Bernhard et al. 2015) instead suggests that there is no apparent correlation between element distribution and surface magnetic induction.

3 Conclusions

The here presented results from our pilot study in the framework of the proposed Czech-Russian project collaboration are very promising and confirm the feasibility of the chosen approach. With the ongoing collection of more and more spectra, we will be able to significantly enlarge the sample of mCP stars with accurate phase-resolved magnetic measurements. The resulting sample, which will also boast ultra-precise light curves from satellite photometry, will be unique and greatly facilitate further research on the connection between the magnetic fields and other parameters in mCP stars.

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