A New Attempt to Detect a Radial Gradient of Large-Scale Magnetic Fields in CP Stars

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Abstract. First observations of several magnetic CP stars were carried out in the spectral range of 3500–4200 Å with the Zeeman analyzer at the 6-m telescope in order to find a radial gradient of their magnetic fields. The first results are obtained for the stars α^2 CVn and 53 Cam.

Keywords: stars: chemically peculiar; stars: magnetic fields
DOI:10.26119/978-5-6045062-0-2_2020_301

1 Task Assignment

An important scientific task is to search for reliable evidence of effective functioning of the mechanism of magnetic diffusion of chemical elements in the atmospheres of chemically peculiar stars with strong magnetic fields (Michaud 1970). It can be solved with high-accuracy spectropolarimetric observations and one can study the manifestations of the magnetic field fine structure including searches for its radial (vertical) gradient. Numerous studies show the predominant role of the dipole component in the structure of the large-scale magnetic fields of these objects.

Since the thickness of the observed atmosphere is 3 orders smaller than the size of the star, then variations in the global dipole field at such small distances should be irrelevant.

However, the studies conducted to date show that there are observation facts that are difficult to explain without involving assumptions about the existence of the radial field gradient in the atmospheres of CP stars measurable by modern methods.

We made the first attempt to measure the effect in the eighties (Romanyuk 1980, 1984, 1986) in the era of photographic observations but with insufficient accuracy.

Due to technical problems, the studies have been suspended for more than 30 years.

The present paper opens a new radial field gradient search program at the MSS spectrograph (Panchuk et al. 2014) of the 6-m telescope with the Zeeman analyzer (Chountonov 2004). For observations, we chose the spectral region from 3500 to 4200 Å. Thus, the spectrum is detected, in which some lines (with $\lambda < 3700$ Å) is formed in the high layers of the atmosphere, and the lines with a longer wavelength—in the deeper layers.

In addition, it becomes possible to measure magnetic fields from the nuclei of 10–11 lines of the hydrogen Balmer series (from Hδ to H-17) which allows one to obtain reliable curves of the longitudinal field from the hydrogen line nuclei, i.e., formed in the upper-layer atmosphere.

For a number of magnetic stars, variability curves of the longitudinal component of the magnetic field have already been obtained with the Landstreet's Balmer magnetometer (Landstreet 1970), but in the wing of the H-beta hydrogen line. They generally fit the curves obtained from the metal lines, however, showed significant differences in details. Since the nuclei of the hydrogen lines are formed in the higher atmospheric layers than the wings, it is of interest to see if there is any difference in the magnetic curves obtained along different parts of the hydrogen line.

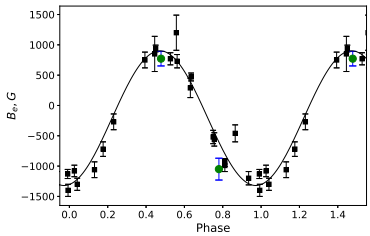

Fig. 1. Comparison of the first data for α^2 CVn [green circles] with the curves of the longitudinal field variability from the Hβ line with the Landstreet's hydrogen magnetometer [black squares].

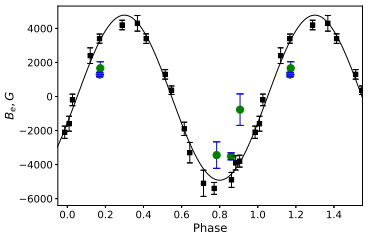

Fig. 2. Comparison of the first data for 53 Cam [green circles] with the curves of the longitudinal field variability from the Hβ line with the Landstreet's hydrogen magnetometer [black squares].

2 First Results

To test this assumption, we carried out observations in March–April 2020 at the BTA Main Stellar Spectrograph in the 3500–4200 Åregion with the R=10000 resolution. In the present paper, the Zeeman spectra of α^2 CVn stars and 53 Cam in different phases of the rotation period were obtained (see at figs. 1 and 2).

For α^2 CV elements from Farnsworth (1932): $JD = 2419869.72 + 5.46939\ E$ were used for phase calculations. And we took the ephemerides of Hill et al. (1998): $JD = 2448498.186 + 8.02681\ E$ for 53 Cam.

One can see that there are differences. Observations will be continued.

Acknowledgements. AVM, IIR thank Russian Foundation for Basic Research (RFBR) No. 18-29-21030, No. 20-02-00233; IAY–No. 19-32-60007. Observations with the SAO RAS telescopes are supported by the Ministry of Science and Higher Education of the Russian Federation (including agreement No. 05.619.21.0016, project ID RFMEFI61919X0016).

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