PROCEEDINGS OF SCIENCE

Statistical physical parameters properties of Ap/Bp-stars in the Orion OB1 Association

Anastasiya Moiseeva,[a,*] **Iosif Romanyuk**[a] **and Vitaly Aitov**[a]

[a] *Special Astrophysical Observatory, Russian Academy of Sciences, Nizhny Arkhyz, 369167 Russia*

E-mail: amoiseeva@sao.ru

The article presents the results of physical parameters ($T_{\rm eff}$, $\log g$, L, M, R, $v_e \sin i$, v_e) study for chemically peculiar stars in the Orion OB1 association. Spectral material of circularly polarized radiation for all CP stars was obtained at the 6-m BTA telescope in the SAO RAS. As a result, no statistical differences were found between magnetic and non-magnetic CP stars of the association. The difference was found for the projection of rotation velocity parameter $v_e \sin i$. However, a detailed study of the equatorial velocity v_e showed that the average value for magnetic does not differ from non-magnetic Ap/Bp stars.

The Multifaceted Universe: Theory and Observations - 2022 (MUTO2022)
23-27 May 2022
SAO RAS, Nizhny Arkhyz, Russia

*Speaker

PoS(MUTO2022)045

1. Introduction

Physical parameters are the basic information that can fully describe and classify stars. The data of stars in clusters or associations, what formed under common origin and matter, gives great importance. The most numerous grouping of early-type CP stars is in the Orion OB1 association. The goals, objectives and selection of research objects are described in paper [1] (59 Ap/Bp stars).

Our previous research [2] showed that no significant differences in physical parameters were found between the subgroups in the association, except for the projection of the rotation velocity $v_e \sin i$: for the 1c subgroup average value was in 2-3 times less than for other. Thanks to the completed analysis of the magnetic field [3–5], in this paper we carried out a statistical analysis of magnetic and non-magnetic Ap/Bp stars of the association.

2. Obtained data and methods

Circularly polarized radiation spectra were obtained with the Main Stellar Spectrograph (MSS) of the 6-m BTA telescope. Instruments, methods of observation and data analysis have been repeatedly described earlier [3–5]. The spectra have an average resolution $R = 15\,000$, signal-to-noise ratio $S/N \approx 200 - 300$ and spectral range $4400 - 5000$ Å what appropriate for analyzing magnetic field and physical parameters. The primary spectra processing and extraction was carried out using standard methods in `MIDAS` context ZEEMAN [6] and `IRAF`.

We used the models of atmosphere method to estimate the $T_{\rm eff}$, $\log g$, $v_e \sin i$ parameters. Comparing the observed hydrogen H_β line profile with the grid of theoretical spectra, the desired parameters were determined using the χ^2 method. For calculation models of atmosphere and synthetic spectra we used `ATLAS9`, `SYNTHMAG` [7] codes and `VALD3` [8] atomic database. To determine luminosity L, radius R and v_e standard formulas were used [9], evolutionary tracks were used to estimate the mass M [10].

For statistical studies, the χ^2 test and the Student's t-test were used.

3. Conclusion

For analysis we used two samples of Ap/Bp stars: magnetic (31 mCP stars) and non-magnetic (28 CP stars). Statistical analysis shows that the average values of the $T_{\rm eff}$, $\log g$, L, M, R parameters have no significant differences between magnetic and non-magnetic Ap/Bp stars. The only difference was revealed in the projection of rotation velocity $v_e \sin i$: for mCP stars this value turned out to be almost in two times less than for non-magnetic CP stars (fig. 1). Additionally, the equatorial rotation velocity v_e studies were carried out using the periods from the our paper [11]. As a result, the average v_e values have no significant differences between magnetic and non-magnetic Ap/Bp stars (fig. 2). This means, that the difference in mean $v_e \sin i$ value gives the inclination angle i. For the next step magnetic modeling for mCP stars in the Orion OB1 association should be carried out to confirm this result.

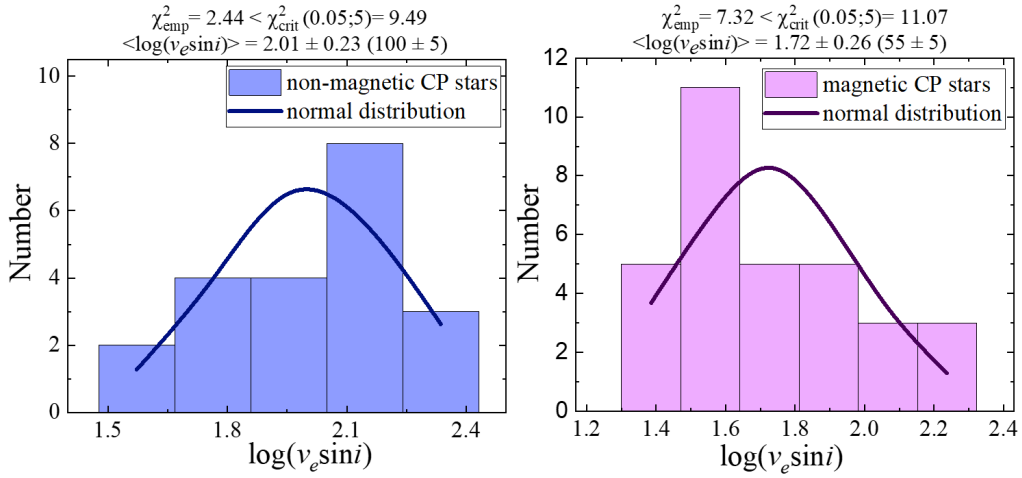

Figure 1: Distribution of projection of rotational velocity $v_e \sin i$ parameter for magnetic and non-magnetic Ap/Bp stars in the Orion OB1 association. Student's t-test values are $t_{\rm temp} = 4.234 > t_{\rm crit} = 2.048$ for $\alpha = 0.05$.

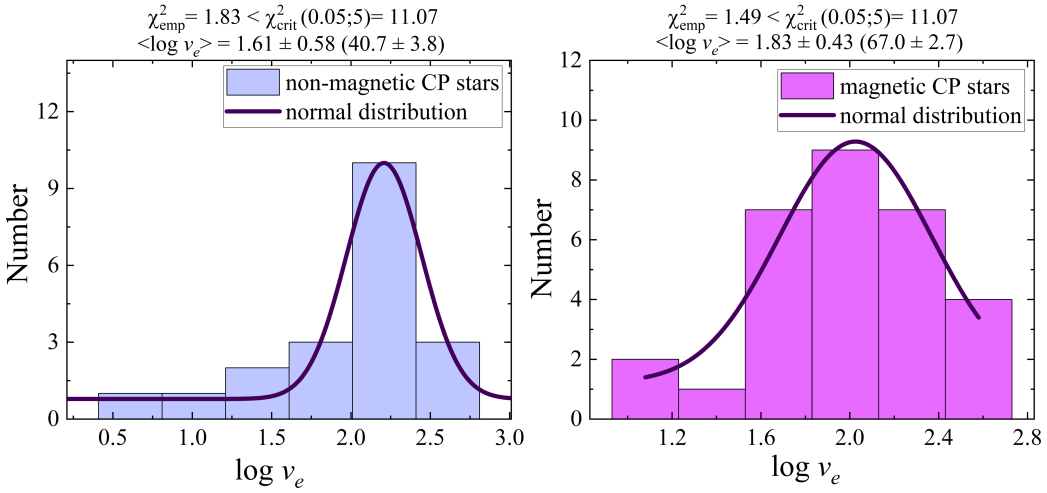

Figure 2: Distribution of equatorial velocity v_e for magnetic and non-magnetic Ap/Bp stars in the Orion OB1 association. Student's t-test values are $t_{\rm temp} = 0.290 < t_{\rm crit} = 2.048$ for $\alpha = 0.05$.

Acknowledgements

The work was carried out with the support of a grant from the President of the Russian Federation for young scientists-candidates of sciences MK-682.2021.6.

References

[1] I.I. Romanyuk, E.A. Semenko, I.A. Yakunin and D.O. Kudryavtsev, *Chemically peculiar stars in the orion OB1 association. I. occurrence frequency, spatial distribution, and kinematics*, *Astrophysical Bulletin* **68** (2013) 300.

[2] A.V. Moiseeva, I.I. Romanyuk and E.A. Semenko, *Chemically Peculiar Stars in the Orion OB1 Association: Determination of Fundamental Parameters*, in *Physics of Magnetic Stars of Astronomical Society of the Pacific Conference Series*, D.O. Kudryavtsev, I.I. Romanyuk and I.A. Yakunin, eds., **518**, (2019), 52.

[3] I.I. Romanyuk, E.A. Semenko, A.V. Moiseeva, I.A. Yakunin and D.O. Kudryavtsev, *Magnetic Fields of CP Stars in the Orion OB1 Association. III. Stars of Subgroup (a)*, *Astrophysical Bulletin* **74** (2019) 55.

[4] I.I. Romanyuk, E.A. Semenko, A.V. Moiseeva, I.A. Yakunin and D.O. Kudryavtsev, *Magnetic Fields of CP Stars in the Orion OB1 Association. IV. Stars of Subgroup 1b*, *Astrophysical Bulletin* **76** (2021) 39 [2104.02434].

[5] I.I. Romanyuk, E.A. Semenko, A.V. Moiseeva, I.A. Yakunin and D.O. Kudryavtsev, *Magnetic Fields of CP Stars in the Orion OB1 Association. V. Stars of Subgroups (c) and (d)*, *Astrophysical Bulletin* **76** (2021) 163.

[6] D.O. Kudryavtsev, *Reduction of Echelle and long-slit Zeeman spectra in Midas.*, *Baltic Astronomy* **9** (2000) 649.

[7] O.P. Kochukhov, *Spectrum synthesis for magnetic, chemically stratified stellar atmospheres*, in *Physics of Magnetic Stars*, I.I. Romanyuk, D.O. Kudryavtsev, O.M. Neizvestnaya and V.M. Shapoval, eds., (2007), 109 [astro-ph/0701084].

[8] T. Ryabchikova, N. Piskunov, R.L. Kurucz, H.C. Stempels, U. Heiter, Y. Pakhomov et al., *A major upgrade of the VALD database*, *Physica Scripta* **90** (2015) 054005.

[9] A.V. Moiseeva, I.I. Romanyuk, E.A. Semenko, D.O. Kudryavtsev and I.A. Yakunin, *Fundamental Parameters of CP Stars Observed at the 6-m Telescope. I. Observations in 2009-2011*, *Astrophysical Bulletin* **74** (2019) 62.

[10] G. Bertelli, L. Girardi, P. Marigo and E. Nasi, *Scaled solar tracks and isochrones in a large region of the Z-Y plane. I. From the ZAMS to the TP-AGB end for 0.15-2.5 {M}$_\odot$ stars*, *Astron. Astrophys.* **484** (2008) 815 [0803.1460].

[11] E. Semenko, I. Romanyuk, I. Yakunin, D. Kudryavtsev and A. Moiseeva, *Spectropolarimetry of magnetic Chemically Peculiar stars in the Orion OB1 association*, *Mon. Not. R. Astron. Soc.* **515** (2022) 998 [2207.00337].