DISCOVERY OF THE FIRST AP STAR IN AN ECLIPSING BINARY SYSTEM

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Abstract. We report the discovery of a very special object, the first star of its kind. HD 99458 appeared to be a chemically peculiar star of Ap type, showing overabundances of Si, Ti and other heavy elements which are concentrated into spots. The spots produce rotational modulation of light variations. In addition, the star shows pulsations of a δ Scuti type, which has never before been reported in Ap stars. The star is in a binary system with a red-dwarf companion, which is also very rare among magnetic chemically-peculiar stars. In this paper we discuss new observations and results concerning the pulsation period and chemical peculiarity of this object.

Keywords: Stars: chemically peculiar, inidividual: HD 99458, binaries: eclipsing

1 Introduction

HD 99458 was originally identified as a candidate exoplanetary host star by Barros et al. (2016). We report here on the analysis performed by Skarka et al. (2019). We utilized *Kepler/K2* data (Howell et al. 2014) and new radial-velocity (RV) observations gathered in the Czech and Slovak Republic to confirm the exoplanetary nature of the companion. We found that the companion is a low-mass red-dwarf star of mass $0.45\,\mathrm{M_\odot}$ and not an exoplanet. High-resolution spectra enabled us to perform a basic chemical-abundance analysis; it revealed that the primary star in the binary system shows overabundance of Si, Ti and other elements. We explain the out-of-transit variations with a period of $2.722\,\mathrm{days}$, which is the same as the orbital period, to be a consequence of chemical spots. The primary of HD 99458 is therefore a magnetic chemically-peculiar star (CP2 type, Preston 1974).

CP2 stars are only rarely reported to be found in binary systems (e.g. Carrier et al. 2002; Mathys 2017). Some unknown process is expected in close binaries that removes the magnetic field, which is necessary to sustain the chemical spots. This makes HD 99458 a special case, and the first A-type CP2 star known to be bound in a close binary system. The analysis of the photometric *K2* data revealed multi-mode stellar oscillations of δ Scuti type, with a dominant frequency at $19.2\,\mathrm{c/d}$ (period of $0.052\,\mathrm{days}$). This phenomenon is also rarely reported among A-type CP2 stars (Bowman et al. 2018). The basic parameters of the binary, (taken from Skarka et al. 2019), are summarized in Table 1.

2 New results and conclusions

In 2019 we obtained new photometry with 60-cm telescope at Mt. Suhora Observatory (Poland) and with the 25-cm FRAM telescope at La Palma (Spain). The photometry in Strömgren filters supplemented with a g2 filter at Mt. Suhora, enabled us to estimate the $\Delta a = +35(3)\,\mathrm{mmag}$ index. That value is typical for stars of the CP2 type (Paunzen et al. 2005). The photometry from the FRAM telescope (Janeček et al. 2019) revealed that the dominant frequency detected in *K2* data by Skarka et al. (2019) was actually the Nyquist reflection of the true dominant frequency, which is $27.72\,\mathrm{c/d}$ ($0.036\,\mathrm{days}$; see Fig. 1). Fututre stages in the investigation of HD 99458 will feature detailed spectroscopic and spectropolarimetric analyses.

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Table 1. Basic parameters of the HD 99458 system. Values are taken from (Skarka et al. 2019), T_0 was adopted from Barros et al. (2016).

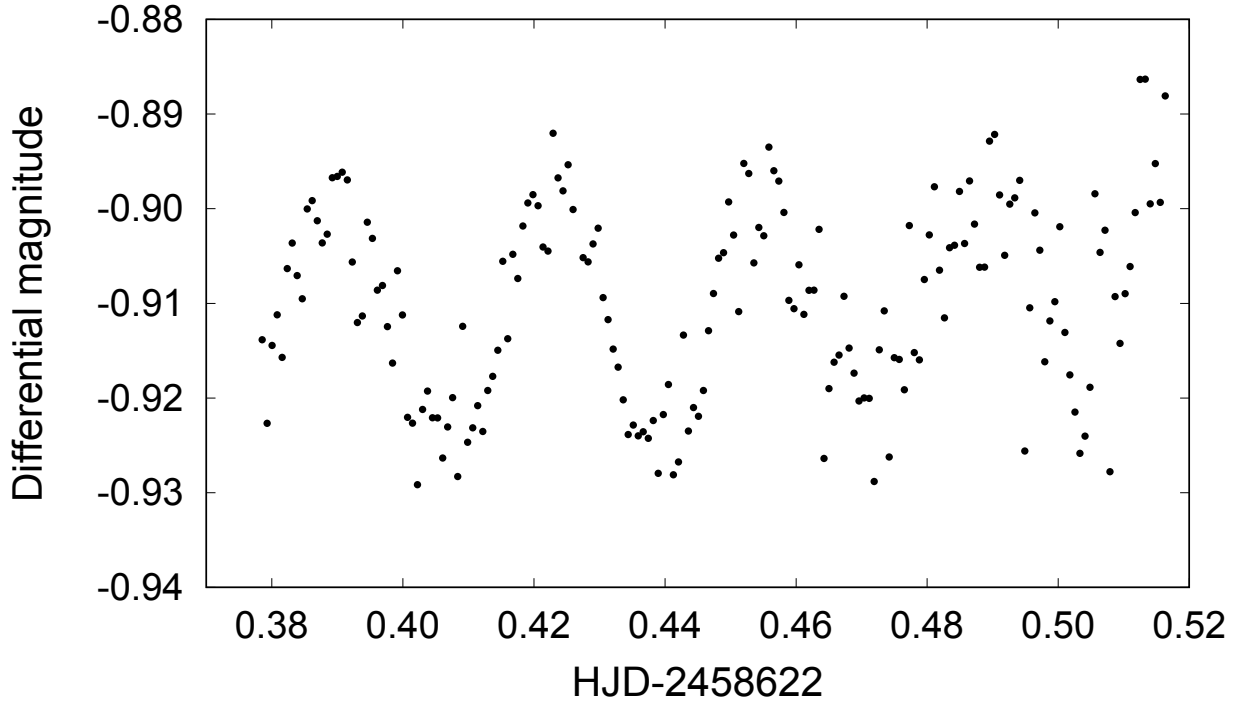|			
P (d)	2.722045(9)	i (deg)	73.2(6)
T_0 (HJD)	2456814.4918	R_1 ($R_\odot$)	3.47(16)
a ($R_\odot$)	11.28(5)	R_2 ($R_\odot$)	$0.59^{+0.06}_{-0.14}$
$q = M_2/M_1$	0.21(1)	$\log g_1$ (cgs)	3.70(5)
K_1 (km s^{-1})	35.2(3)	$\log g_2$ (cgs)	4.55(5)
M_1 ($M_\odot$)	2.15(5)	M_2 ($M_\odot$)	0.45(2)

Fig. 1. Observations in Johnson B taken with the FRAM telescope.

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