Cyclotron Harmonics and Zeeman Features in the Spectra of the Polar BS Tri

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Abstract. The cyclotron harmonics were found in the spectra of the polar BS Tri. Their wavelengths correspond to the magnetic field strength $B = 22.2 \pm 0.5$ MG. The spectra exhibit absorption components of the Zeeman splitting of the Hα line formed in magnetic field of 21.5 ± 1 MG. The observed features of the spectra suggest that a cold halo exists around the accretion spot in BS Tri.

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1 Observations

The spectral observations of BS Tri were carried in the night 21/22 Sep 2011 by 6m telescope BTA of Special Astrophysical Observatory of Russian Academy of Sciences. The telescope was equipped with SCORPIO-2 spectrograph providing coverage of $4000-7200$ Årange with the resolution $\Delta\lambda = 2.6$Å/pix. The spectral images were reduced by the IRAF package in a standard fashion.

2 Cyclotron Harmonics

The obtained spectra can be devided into two groups. The first group of spectra was obtained in the range of orbital phases $\varphi = 0.60 - 1.21$ ($\varphi = 0$ corresponds to the middle of the eclipse), where the two-humped brightness maximum is observed. During this period spectra have "humps" which can be interpreted as cyclotron harmonics originated in accretion spot. The spectra of second group belong to phase interval $\varphi = 0.21 - 0.60$, where cyclotron harmonics are disappeared. Apparently, the first group of spectra was obtained during the passage of the accretion spot over the disk of the white dwarf. These spectra, cleared

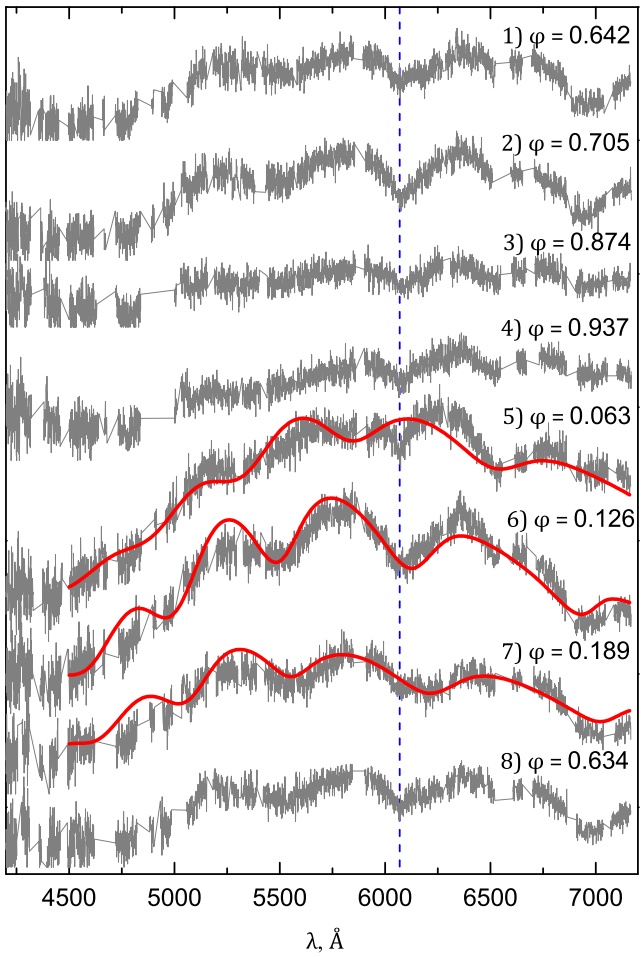

Fig. 1. Cyclotron spectra of the polar BS Tri. Theoretical spectra are superimposed on the observed cyclotron spectra 5-7. The vertical dashed line points to the position of 6075 Å absorption feature.

of emission and telluric lines, are shown in the fig. 1. In addition to cyclotron harmonics, the absorption-like feature at a wavelength of 6075 Åis distinguished in the spectra. This feature does not change its position during the observation and is manifested only in the spectra of the first group.

The spectra No. 5–7 were modeled by the simple model of cyclotron emission region. The emission region was assumed to be temperature and density uniformed. The solution the radiative transfer equation for ordinary (+) and extraordinary (–) waves has the simple form:

$$I_{\pm} = \frac{\mathfrak{B}}{2}\Big(1 - \exp(-\alpha_{\pm}\Lambda)\Big), \tag{1}$$

where $\mathfrak{B}/2$ is the Planck function per polarisation mode, $\alpha_{\pm}$ are absorption coefficients in units $\omega_p^2/\omega_c c$ ($\omega_c = eB/m_e c$ — cyclotron frequency; ω_p — plasma frequency), $\Lambda = \omega_p^2 \ell/\omega_c c$, ℓ is the geometrical length of emission region along line of sight. The absorption coeffcients were calculated using the technique described by Chanmugam & Dulk (1981). The total intensity is found by summing the intensities of the two polarization modes: $I = I_+ + I_-$. The found magnetic field strength in accretion spot is $B = 22.2 \pm 0.5$ MG.

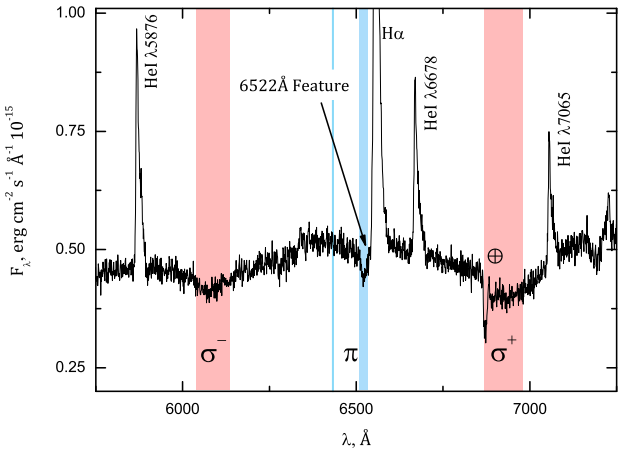

Fig. 2. Zeeman absorption feature in BS Tri spectrum. The position of π and σ-components for $B = 21.5$ MG are shown by filled regions.

3 Zeeman Features

The spectrum No. 2 has an absorption feature at $\lambda = 6522$ Å (see fig. 2). This feature can be interpreted as the π-component of Zeeman splitting of Hα line formed at magnetic field strength $B = 21.5 \pm 1$ MG. At the same magnetic field, the wavelengths of the σ^--components are in good agreement with the position of 6075 Å feature. Considering that the 6075 Å feature is observed only together with cyclotron harmonics, we can assume that the accretion spot is surrounded by a cold halo. Wickramasinghe et al. (1987) as well as Schwope & Mengel (1997) came to the same conclusions when studying polars V834 Cen and EP Dra, respectively.

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