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MODELING THE OPTICAL SPECTRA OF RHO LEO

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We present the results of the optical spectroscopic analysis and modeling of B1a star ρ Leo. We have analysed spectra of rho Leo obtained with the 6-m BTA telescope (Special Astrophysical Observatory, Nizhnij Arkhyz, Russia) using the SCORPIO focal reducer. We obtain the stellar parameters and chemical abundances of rho Leo comparing models with the observed spectra. Model spectra were calculated using non-local thermodynamic equilibrium (non-LTE) radiative transfer code CMFGEN. We find temprature $T_{\rm eff} = 23500$ K, luminosity $L = 2.8 \times 10^5\, L_\odot$, radius $R = 31\, R_\odot$, mass $M = 28\, M_\odot$, $\log g = 2.88$ and mass-loss rate in the range $\dot{M} = 9.55$–$15.0 \times 10^{-7}\, \dot{M}_\odot \mathrm{yr}^{-1}$. We investigate the impact of an enhanced mass loss rate on the H_β, H_γ and helium line profiles.

Keywords: radiative transfer – stars: fundamental parameters – stars: atmospheres

1. INTRODUCTION

The line profiles in spectra of OBA stars are variable on the time scales from days to hours [1]. This work continuates the study by Kholtygin et al (2018) [2] of the short-period line profiles variability of B1a supergiant ρ Leo.

As shown by Kholtygin (2018) [2], ρ Leo has periodic profile variations of H and He lines with periods from 2 to 90 minutes and irregular variations on a subminute time scale. Perhaps the changes in the contribution of the emission component to the line profiles (due to the instability of the stellar wind or additional emission from the shock waves in the wind) can cause variations in the line profiles on the second time scale. To estimate the contribution of the emission component to the line profiles, it is necessary to determine all main stellar ($\log g$, $T_{\rm eff}$) and wind ($\dot{M}$, V_∞) parameters.

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2. OBSERVATIONS AND DATA REDUCTION

ρ Leo spectra were obtained with the 6-m BTA telescope using SCORPIO spectograph on 19–20 January 2015 with in spectral ranges 4050–5830Å. The spectral resolution was 2000 (slit width 0.5"). The exposure time is 1–2 seconds. During the observations, 1271 star spetra were obtained.

3. METHODS AND RESULTS

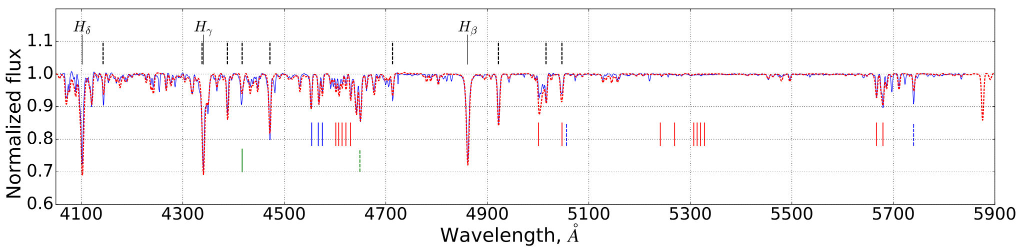

Fig. 1. The mean ρ Leo optical spectrum (solid blue line) compared to the best-fit model (solid red line). The spectral lines are marked with the black solid lines (He I), red solid lines (N II), blue solid lines (Si III), blue dashed lines (Si II), green solid lines (Fe II) and green dashed lines (O II).

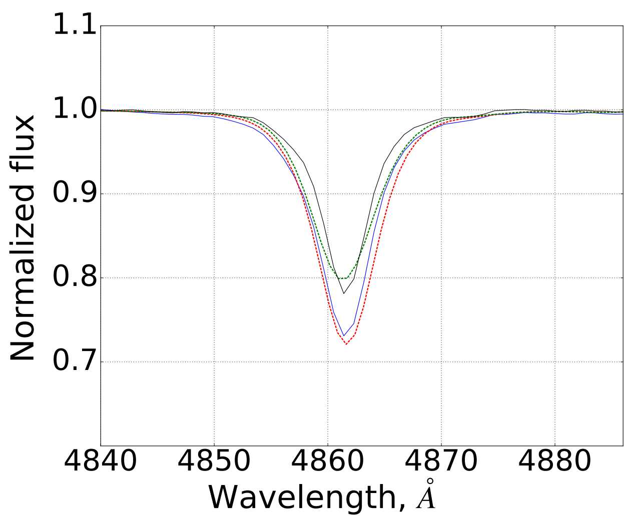

Fig. 2. Mean ρ Leo spectrum (solid blue line) and best-fit models (red dashed line, $\dot{M} = 9.55 \times 10^{-7} M_\odot \mathrm{yr}^{-1}$, $\beta = 1.0$). The most deviating from the average ρ Leo spectrum (black solid line) is modelled with an enhanced $\dot{M} = 1.50 \times 10^{-6} M_\odot \mathrm{yr}^{-1}$, $\beta = 1.5$ (green dashed line).

For our analysis of the optical spectra we have used the iterative non-LTE line-blanketing code CMFGEN [3], velocity structure was approximated by simple β law.

The mean spectrum and best-fit model are presented in Figure 1. We present main stellar parameters and chemical abundances of our best-fit model for ρ Leo in Tab. 3 and 3. In this work, we investigated influence of the emission component to line profiles. The emission component of line profiles can be changed due to the mass-loss rate variations in the magnetized stellar wind and gas emission after shock waves. In Figure 2 we present Hβ line profile of the mean and the most deviating from the average spectrum. There are also several models at different mass loss rates (we applied typical values of X-ray luminosity for OB stars in Galaxy for our models). We did not find a significant contribution of the X-ray emission to line profiles for mass loss rates $\dot{M} \sim 10^{-6}$–$10^{-7}\, M_\odot \mathrm{yr}^{-1}$. As shown in Figure 2, the significant deviation of the Hβ line profile from the average corresponds to an increase in the mass loss rate by $> 60\%$.

	$\log L_*$ $[L_\odot]$	R $[R_\odot]$	$\log g$	$T_{\rm eff}$ [kK]	$\log \dot{M}$ $[M_\odot \mathrm{yr}^{-1}]$	v_∞ [km s^{-1}]	β
ρ Leo	5.45	31	2.88	23.5	$-(5.8$–$6.0)$	1100	1–1.5

	$X_{\rm H}$ [%]	$X_{\rm N}/X_\odot$	$X_{\rm C}/X_\odot$	$X_{\rm O}/X_\odot$	$X_{\rm Si}/X_\odot$	$X_{\rm Fe}/X_\odot$
ρ Leo	55	5.81	0.72	0.13	0.78	0.71

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