The first spectra for the RX J0440.9+4431 from 2m Terskol telescope

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We present the first results on the spectra of Be/X-ray binary RX J0440.9+4431 obtained with the 2m Ritchey-Chretein-Coude telescope with Cassegrain Multi Mode Spectrograph (CMMS) (with $R = 14000$) at Terskol observatory. The H_α line profile indicates that the new episode of the V/R variability is occuring in the system. The profiles of the H_α, H_β and He I 7065.71, 6678.15, 5875.97 lines were analyzed and equivalent width were determined. We compared our H_α line profile parameters with the previous results from Reig et al. (2005) and estimated characteristic time scale for disc changes as about 14 years.

Introduction

RX J0440.9+4431 belongs to the most numerous class of high-mass X-ray binaries — Be/X-ray binaries. The system has two components: a blue main sequence star B0.2Ve [5] and neutron star orbiting around it. This object belongs to the relatively bright X-ray sources with $V = 10.78$. Its spectra show a long-term variability of the Balmer and He I double-peaked emission lines. As an X-ray pulsar it has a pulsing period of 202 s [4] and suspected orbital period over 150 days. The distance to the object was estimated as about 3.3 kpc [5].

Observations

Spectral observations were obtained with the help of the 2m Ritchey-Chretein-Coude telescope with CMMS at Terskol observatory on February 2–3, 2010. Spectrograph was equipped with a diffraction echelle grating with 75 grooves per millimeter and a blazing angle of 63.5°. Diffraction grating with 300 grooves per millimeter and a blazing angle of 4° was used as a cross-disperser. During these observations three echelle spectra with 30-minutes exposures were obtained. From these spectra a median spectrum was compiled for further analysis. This spectrum contains 28 echelle orders and covers a spectral range of $3900 - 7500$ Å. Within this range the dispersion varies from 0.12 Å/px to 0.25 Å/px. But due to the low signal-to-noise ratio in blue region we used for our analysis only the data with $\lambda > 5000$ Å. In the region of the H_α line signal-to-noise ratio is ≈ 100.

The data reduction was performed with the help of `Dech95` software and spectra analysis was provided with `Dech20T` software [1, 2].

Results

We found and analyzed five double-peaked symmetric class 1 (according to classification in [3]) emission lines in the spectrum: H_α, H_β and He I 7065.71, 6678.15, 5875.97 lines. We should mention that the last asymmetric profile for the H_α line was seen in 1996. For all of these lines we calculated $\log(V/R)$, equivalent width, mean intensity of the blue and red peaks over the central depression and peaks separation. All these values are presented in Table 1. As we can see, all our data for the H_α line are in good agreement with [5].

We also studied the radial velocities fields and general structure of the line profiles. All of these lines are shifted blueward. First of all we found that some of the V and R peaks have their own two peaks — right and left ones with a gap between them. Except this, our attention was attracted to the features with width of about 94 km/s and 111 km/s in He I lines: for these velocities the intensity of He I 7065.71 and He I

5875.97 anti-correlate with the intensity of He I 6678.15, but it is necessary to confirm this fact in the further investigations. It is worth to note that the same lines have different sign for $\log(V/R)$ value (see Table 1).

After analyzing the data from [5] (Table 1 and Fig. 3) and comparing those data with our ones we can make some assumptions about time scale of disc changes. EW and the shape of H_α line profile are very similar to the profiles at the end of 1995 and beginning of 1996. In addition, H_β profile in our data, first time after the end of the 1997, shows emission with the approximate value of EW≈ -1.2 Å — the largest negative value for the whole history of the object observations (since March, 1, 1996 for H_β line). Taking into account all these facts we can suggest that the characteristic time scale of the disk changes in RX J0440.9+4431 system is about or more than 14 years.

Table 1: Emission line parameters

Line	$\log(V/R)$	EW, Å	$\triangle_{peak}$, km/s	I_p/I_{cd}
He I 7065.71	-0.12	-1.05±0.10	406	1.23
He I 6678.15	0.05	-0.65±0.10	284	1.10
He I 5875.97	-0.31	-0.78±0.10	342	1.14
H_α	-0.06	-9.8±0.8	298	1.20
H_β	-0.21	-1.18±0.05	365	1.24

Conclusions

The results of the preliminarily analysis of the Be/X-ray binary RX J0440.9+4431 spectra, observed at Terskol observatory are in a good agreement with previous results by other authors. The appearance of the asymmetric profiles of emission lines indicates that the new epoch of V/R variability has been started. This fact allows us to conclude that the time scale of the disc evolution is about 14 years or larger.

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