Peremennye Zvezdy (*Variable Stars*) **32**, No. 5, 2012

Received 7 August; accepted 16 August.

Spectroscopic Evidence for Appearance of a New Decretion Disk Around IGR J06074+2205

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We report on a new episode of decretion disk formation in the IGR J06074+2205 system. Our spectroscopic data permit us to measure peak separation in the double-peaked Hα line as 408 ± 55 km/s and hence to determine the disk radius as 1.6 star's radii. These findings permit us to predict possible new X-ray activity of IGR J06074+2205 in the nearest future.

1 Introduction

IGR J06074+2205 is a neutron-star Be/X-ray binary of the B0.5V spectral type. The distance to the object is about 4.5 kpc. From a study of three HeI lines, the rotational velocity of the star was determined as 260 ± 20 km/s. After five years of spectroscopic monitoring of IGR J06074+2205 (Reig et al. 2010), a reversion from emission to absorption of the Hα line and hence disappearance of the equatorial disk was reported. The total disk disappearance was observed in March, 2010, when the Hα line profile became a completely absorption one.

In general, disk appearance and disappearance episodes are usual for Be/X-ray binaries, but disk loss episodes are observed more frequently. It is currently known that decretion disks in such systems exist for about 3–7 years (see Table 5 in Reig 2011) and typical disk loss episodes last about 1.5–2 years. Because of absence of sufficient amount of information about episodes of disk appearance and growth, we aimed at studying disks in the phase of their formation; IGR J06074+2205 can be the first candidate for such a study.

2 Observations and Data Reduction

IGR J06074+2205 was observed on April 14 and April 24, 2012 at the International Center for Astronomical, Medical, and Ecological Research with the 2-m Ritchey–Chrétien–Coude telescope and the Cassegrain Multi-Mode Spectrograph (CMMS) ($R = 14000$) as a part of spectroscopic monitoring of selected Be/X-ray binaries. On each of the two nights, we obtained one spectrum of the object with a $2700^{\rm s}$ exposure time (Simon et al. 2012). Calibration frames were taken on the same nights. For our analysis, we used only one order with the Hα line from the whole echelle spectrum. The signal-to-noise ratio (SNR) in the Hα region is 10.

We reduced the data using the Dech95 software written by Galazutdinov (2007). Due to the low SNR, it was impossible to use bias and dark frames for calibration because of presence of negative pixel intensities in the resulting frame. Thus, we decided to subtract the noise measured to both sides of the order from the selected echelle order. The subtracted spectral orders were analyzed with the Dech20T software, also by G.A. Galazutdinov. To find the dispersion curve, we used a spectrum of a Fe–Ar lamp as well as the daylight spectrum. From the dispersion curve, we determined the spectral dispersion as 0.25 Å per pixel.

3 Data Analysis and Results

Using our spectra of IGR J06074+2205 obtained on April 14 (the black curve in the Figure) and on April 24 (the red curve), we can clearly identify a double-peaked Hα emission line and detect its V/R variations. Appearance of the Hα emission line can indicate appearance of the equatorial disk around the Be star. In spite of the high noise level of the spectra, it is possible to conclude that the symmetric Hα line has a shell profile with FWHM = 12.4 ± 0.5 Å. The peak separation for this line is 408 ± 55 km/s. Taking into account the star's rotational velocity, 260 ± 20 km/s (Reig et al. 2010) and the correlation between star and disk radii, one can obtain the disk radius of about 1.6 star radii.

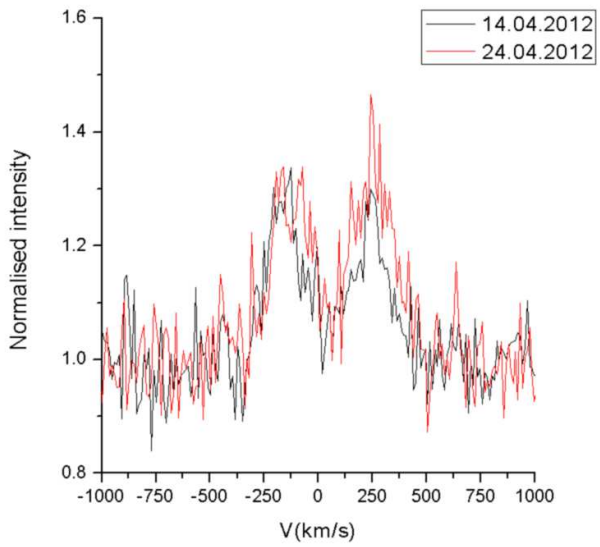

Figure 1. Two Hα line profiles obtained on 2012 April 14 (black) and April 24 (red).

4 Discussion

The timescale between full disk disappearance (Hα in absorption) and its next appearance (Hα in emission again) is no more than 26 months (or about 2 years) in the case of IGR J06074+2205. The actual timescale may be smaller due to absence of observations during these two years. For example, in some other objects, the time between the last-observed absorption and first-observed emission in the Hα line is believed to be about several

months. In the case of A0535+26 (see Fig. 2 in Haigh et al. 1999), this timescale is about 3 months. For V635 Cas (Negueruela et al. 2001), only 2 spectra separated with 4 months were obtained, which show a change from absorption to emission. However, there exist other systems, such as X Per (Clark et al. 2001) and RX J0440.9+4431 (Reig et al. 2005), that did not show any absorption lines during their disk loss episodes. Their Hα profiles were mostly flat like continuum (X Per) or showed a very weak emission (EW ≤ 1).

The re-appearance of the disk and its small size (1.6 star radii) permit us to predict a new episode of optical and possible X-ray activity of IGR J06074+2205 in the nearest future, with V/R variations and an increase of the IR excess. Further spectroscopic and photometric observations in the optical and IR ranges are encouraged; they will be useful for understanding disk formation mechanisms.

Acknowledgments: This work was supported by the International program "Astronomy in the Elbrus region (2010-2014)" of the International Center for Astronomical, Medical, and Ecological Research (ICAMER). We thanks the ICAMER staff for their assistance during our observations.

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