ON PERIODIC VARIATIONS IN THE SPECTRUM OF THE BOe STAR X PERSEI ASSOCIATED WITH THE X-RAY SOURCE 3U 0352+30

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The bright BOe star X Persei has been observed for over fifthy years, both as an emission line object and as a variable star.

The discovery that the star is situated very close to the position of a weak X-ray source renewed the interest on the star and up to the present it has been under close scrutiny by a number of observers.

In the course of an investigation of all available spectroscopic data, Hutchings (1974) found evidence for a long period absorption velocity variation, that may indicate the presence of a massive orbiting companion. A period of about 581 day was found by Hutchings for the broad Balmer absorption.

Then the 22-hr and 13,9 min periodicities were discovered in the X-ray range between 0.6 and 7.5 keV. However the search for the 22.4 hr periodicity in the radial velocity data made by Hutchings (1977) was not successful.

At the Crimean Observatory the spectroscopic observation of X Persei has been started in November 1974. The spectrograms with dispersions 30 and 36 A/mm in the regions Hα and at λλ 4950-3650 A were obtained from November 1974 to December 1980 ; about 2000 days were covered by us observations.

The search for the evidence for the periodicities of 581 day and for the 22 hr in the variations of the radial velocity was made by us using the homogeneous observations from November 1974 to March 1978.

On figure 1 can see that the broad Balmer absorption shows the period of 581 day in the variations V_r as found by Hutchings, but the velocity amplitude proved to be about 50 km/sec.

HeI lines revealed variations of V_r with a velocity amplitude of $\pm$ 22 km/sec and a large scatter in the measurements ; furthermore the phase

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is shifted by about one forth of the period, relative to the Balmer absorption data.

The variations of V_r derived from the violet emission component of the Hα line have an amplitude K = 30 - 35 km/sec. However, in the phases $0^P.45$ - $0^P.70$ a large scatter of values of the radial velocities (V_r) was observed.

The radial velocities derived from the V and R emission edges of the Hα line were analysed for a search of the variations with 22.4 hr period.

To this purpose our observations from November 1976 to January 1978 were divided into groups, the time intervals used being a short interval of the 580 days period, in view of the superposition of the rapid rotational and orbiting motions and of the proposed apsidal and other motions.

In the second figure one can see the variations of the radial velocity derived from the shifts of emission V and R edges of Hα line with the phase of the 22.4 hr period (top curve). The zero point has been taken arbitrarily as the moment of the minimum of the intensity ratio of the violet to red component (I_v/I_R) of the Hα line emission. The phase dependence of the V/R intensity ratio has been shown on the bottom curve. After 1978 the spectroscopic observations X Persei were continued.

The observations of last season (1979-1980) have lead to a reexamination of the 581 day period, because the measurements of radial velocity revealed a large scatter in the phases of this period.

A search of the new period of the variations was made. According to our homogeneous spectral observations carried out at the Crimean Astrophysical Observatory from XI.1974 to I.1980, a new period of radial velocities variations has been found, its value being, 308,33 days.

On the third figure one can see the variations of radial velocity from the broad Balmer absorption line (HI λ 3835), and from the components of the Hα line in this period. Let us note that the relative intensity of the V and R components of the Hα line is changing with about the same period. We assume, therefore that the real orbital period is equal 308,33 days.

For the check the 22,4 hr periodicity the observations of X Persei were taken in interval of 10 days (from 9 to 20 October 1980). We assume that this short (10 days) interval, decreases the influence of the orbital motion with large period and large amplitude.

On figure 4 one can see the results of the measurements V_r in the phase of 22,4 hr period for the R (top) and V (bottom) components of the Hα line emission. Also the 22,4 hr periodicity in the variations of radial

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velocities of the Hα line components, found by us before (Izv. Cr. v. 61, 1980) is confirmed.

This lead us to the evident conclusion about the relation between X Persei and the X ray source 3U 0352 + 30. One notices that if the radius of the B0e component is taken equal to 4,9 solar radü and V sini = 270 km/sec, the period of rotation would be equal to 22,5 hrs.

In figure 5 one can see the variations in I_V/I_R with time (top) and the corresponding variations of the radial velocity of the V_{em} edge and the absorption core of the Hα line (bottom). Three I_V/I_R reversals occur. The time interval between two succesive reversals is about 300 days.The amplitude of I_V/I_R variations seems to differ from cycle to cycle.

On figure 6 one can see the intensity variations of the V (o) and R (x) components with the phase of the period $308^d.3$. We see that the intensities of the V and R components of the emission line Hα change in antiphase. On the regular variations with a period of $308^d.3$ of V and R are superimposed irregular short time scale pulsations that may be due to irregular matter ejection from the star.

About twenty years ago Boyarchuk showed that the stationary outflow cannot originate from the equatorial region of Be star, but that active processes of irregular nature occur on the stars surface. Our observations confirm this idea.

The ratio I_V/I_R, as Boyarchuk remarked, might be the measure of the expantion velocity of the Be star envelopes. When $I_V > I_R$ the envelope contracts ; when $I_V < I_R$ the envelope extends. But the envelope as a whole can not phase.

Possibly these irregularities are conected with the interaction between the components of the system X Persei/ X Ray 3U 0352+30.

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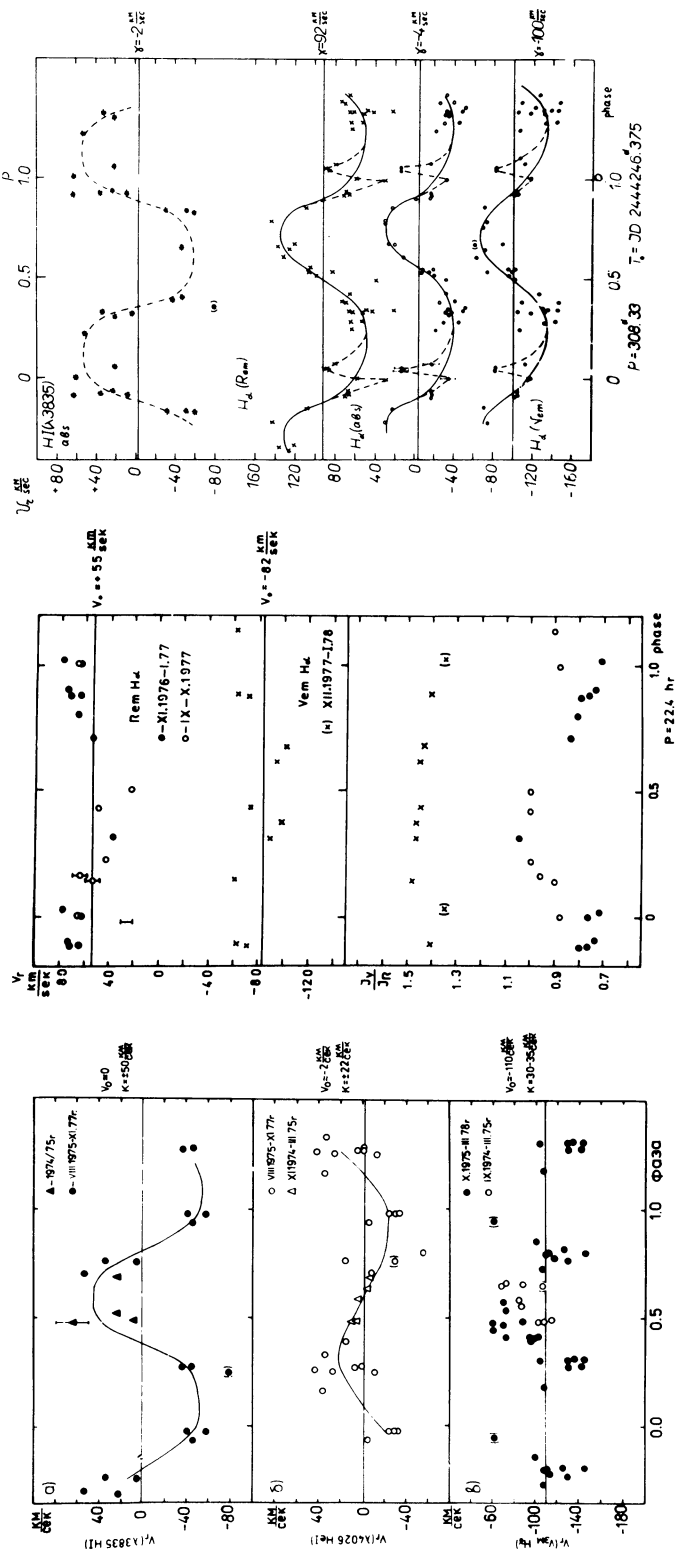

Figure 1.

Figure 2.

Figure 3.

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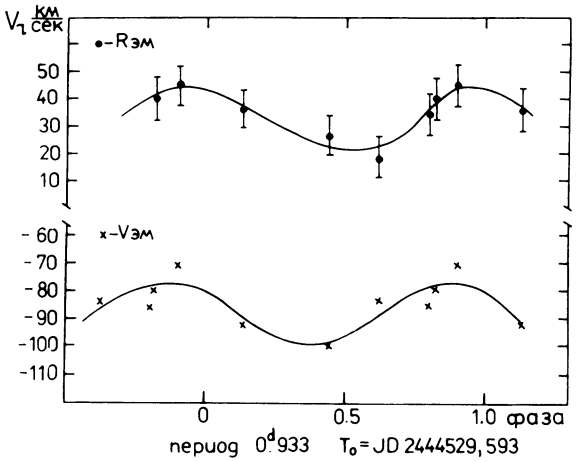

Figure 4.

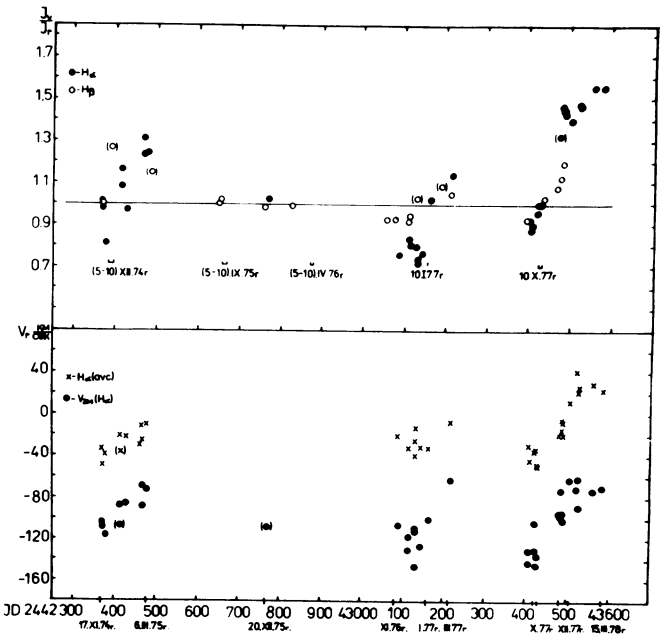

Figure 5.

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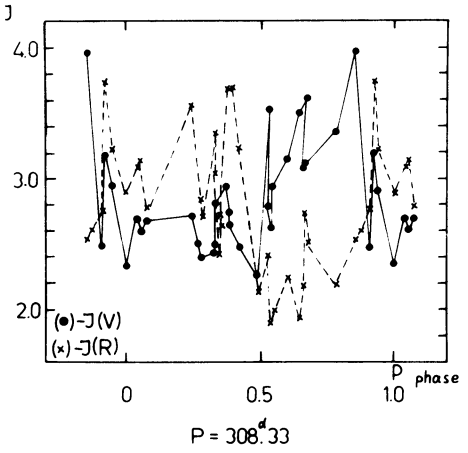

Figure 6.

DISCUSSION

Viotti: Concerning the long-term spectroscopic variations of X Per it is known that during the last years the star suffered large luminosity variations with two maxima in 1978 and 1980. It might be possible that the spectroscopic variations are more or less correlated to these luminosity variations rather than to any kind of long-term periodicity.

Galkina: I have made comparisons of the variations of the relative intensity of the V and R components of the emission line H_α with the photometric bahaviour of X Per in 1974 - 1977. The spectroscopic and photometric variations were correlated.

Henrichs: The 22 hour period in the x-ray flux reported by White et al. (MN 176, 1976) has never been confirmed by any other x-ray measurement. My question is: would you have found this 22 hour period in your optical data without knowing it beforehand, or did you only fold the data with that period? In the latter case one should be very cautious to call the result a confirmation, especially in the case of such an irregular varying star like X Per.
Galkina:I have discovered a 22.4 hour periodicity of the variations of the radial velocities from the emission V and R components of the H_α line in 1978.
From 1980, October 9 to 20 I have made spectroscopic observations of X Per. These observations confirmed the 22.4 hr periodicity in the variations of the radial velocities.

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