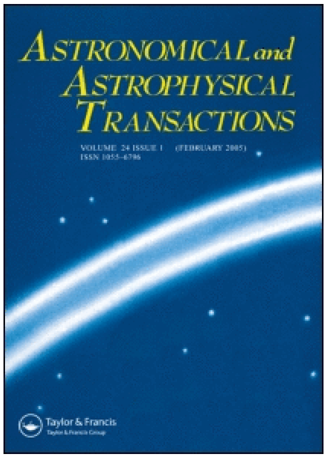

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Photometric and polarimetric observations of HDE 245770 = A0535 + 26 during an X-ray flare

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PHOTOMETRIC AND POLARIMETRIC OBSERVATIONS OF HDE 245770 = AO535 + 26 DURING AN X-RAY FLARE

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The results of photometric and polarimetric observations (March–April, 1989) are given for the Be star X-ray binary AO535 + 26. These observations were made before, and during, an X-ray flare.

KEY WORDS X-ray sources, transients, photometry, polarimetry.

Among X-ray sources there is a class of so-called, transient X-ray sources. Several hard, pulsating, X-ray transients are associated with Be stars. Their common feature is that they present a very considerable variability with different time scales.

In this paper we give the results of new photometric and polarimetric observations of the HDE 245770 = AO535 + 26 in March–April, 1989 before, and during, an X-ray flare of this source. The photometric behaviour of HDE 245770 was studied by several researchers. A detailed analysis was given by Giovannelli *et al.*, 1985. The latest data are given by Gnedin *et al.*, 1988a. The latest important result is due to the discovery of a long-term variability of AO535 + 26 in the optical range (Figure 1). Optical data show a long-term period of ~1100 days. This result was confirmed by ASTRON data (Gnedin *et al.*, 1988b).

Transient X-ray source AO535 + 26 has been active since March 28, 1989 (Makino, private communication). The X-ray intensity in Ginga energy range was 0.33 Crab on March 30. Sunayev (private communication) reported the data of Observatory RENTGEN from modulus KVANT of Soviet Orbital Station MIR: the flux in hard X-ray energy range was 3.5 Crab on the 7th of April.

This paper gives results of observations of AO535 + 26 in March–April 1989.

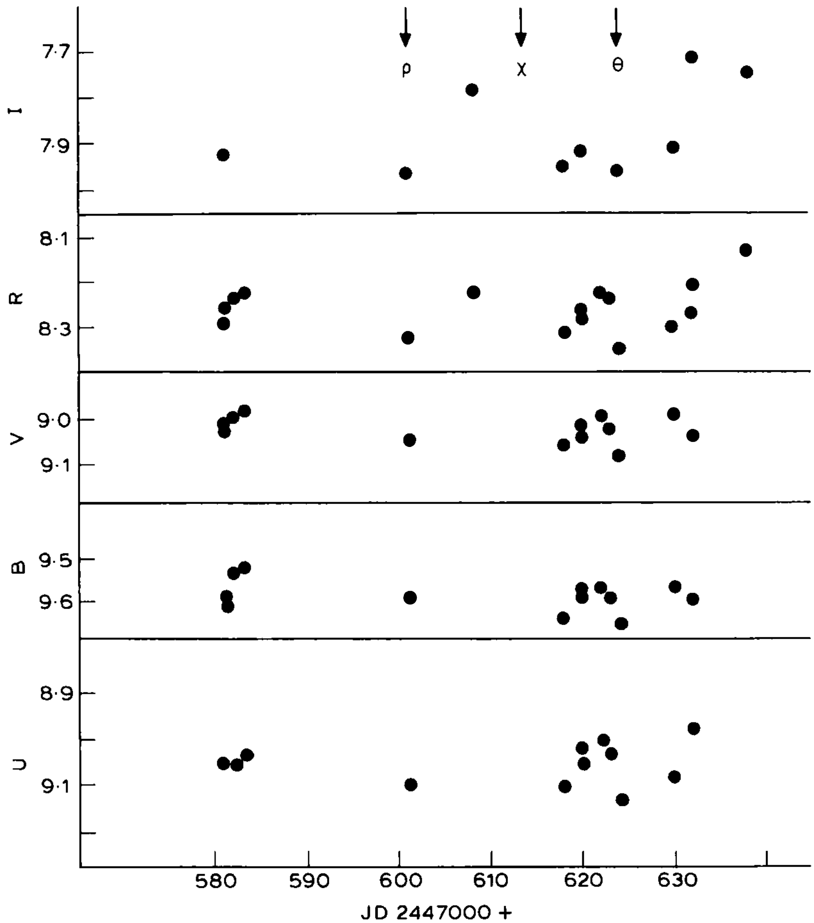

Figure 1 The UBVRI photometry of AO535 + 26 close to the 1989 March X-ray flare. The moments of the onset of the flare (x), rapid changes in the intrinsic polarization degree (P), and position angle (O), are shown by arrows. For the explanation, see the text.

The data used for the analysis were obtained with the following instruments: 2.6 m telescope of the Biurokan Astrophysical Observatory with the photometer-polarimeter of Astronomical Observatory of Leningrad University (JHK photometry); 50–70 cm telescopes (UBVRI photometry) of Astronomical Observatory of Leningrad University; the Sternberg Astronomical Institute and Central Astronomical Observatory at Pulkovo; 1.25 m telescope of Crimean Observatory (UBVRI photometry and polarimetry); 6 m telescope of Special Astrophysical Observatory (spectroscopy and polarimetry in H_β and the continuum).

1. Let us first of all mention the characteristic differences of optical behaviour of AO535 + 26 during this flare, compared to the previous flares of 1983 and 1986. Those flares were accompanied by a noticeable drop of optical and infrared brightness, the amplitude of this drop increasing with wavelength (see Figure 1 in Gnedin *et al.*, 1988b). This anticorrelation was explained as being due to

accretion of matter from a disk-accumulator and a corresponding decrease of its dimensions. The March flare optical and infrared brightnesses were at the level of a "quiet state". Only at the *U* band the brightness was ~$0^m.1$ lower (Figure 1). On March 13 Liutyi (private communication) reported a brightness drop in all the bands by ~$0^m.2$. The colour indices, *U–B* and *B–V*, became noticeably redder. It is important that this event was just preceding the X-ray flare. The last R, I points (10–20 April) were by $0^m.1$–$0^m.15$ brighter.

2. Spectrograms of AO535 + 26 with the dispersion 28 A/mm in the 3500–7000 Å range were obtained with the 6 m telescope on 26, 27 February, 16, 21 and 23 March (Fabrika, private communication). The expected increase of the H_γ and H_β emission lines was not observed. On the contrary, the lines appeared to be weaker than in the usual state.

3. For analysis of the broad-band polarimetric data, we used interstellar polarization data obtained by Larionov, 1987: $P_{in} = 1.28\%$, $O_{in} = 160°$. The mean level (March–April) of the intrinsic polarization corresponds to the level of the bright optical state, and in some cases a bit higher. During one night before the flare, (15th of March, two days after the brightness drop recorded by Liutyi) the intrinsic polarization net was to be twice higher (*V, R, I* bands) than the usual value for the same position angle and usual brightness level (Figure 2). A 10° deviation of the position angle in all colour bands was noticed on April 4. At this moment the brightness level was by $0^m.1$ lower than before and after that day. If one suggests that polarized radiation is produced in an accretion disk, or Be star

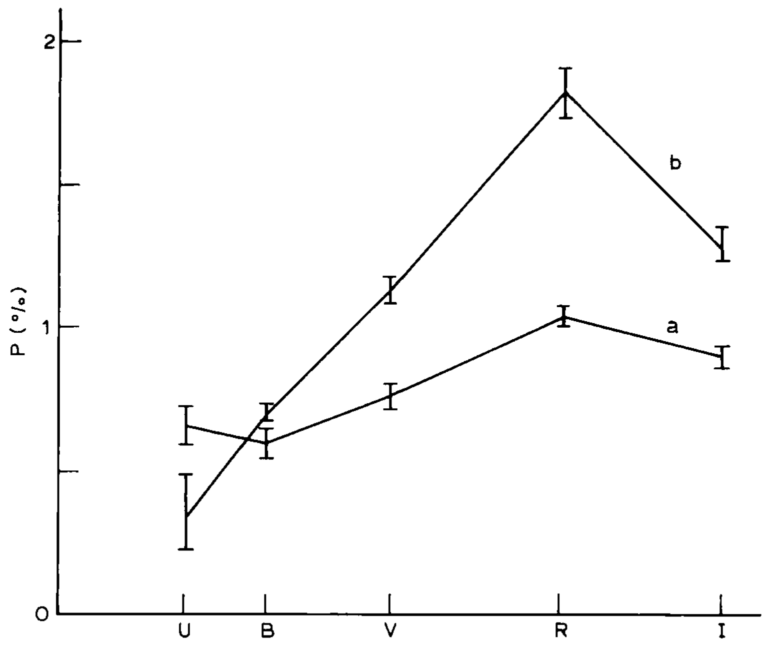

Figure 2 The intrinsic polarization degree of AO535 + 26 in 1989 March–April: (a) data averaged over 5 observing nights; (b) dependence of polarization on the wavelength on March 15 (JD 2447601.2).

Table 1 The polarization date of H line profile.

Date	*P%*	0°	
16/17.03.89	1.28	145.1	red wing
	0.95	161.1	blue wing
	0.55	156.0	continuum
17/18.03.89	0.86	163.8	continuum

envelope, this fact means that the geometry of the radiating region was changed, but its volume keeps constant.

4. Spectropolarimetry in the continuum near H_β (17 and 18 March) agrees quite well with broad band polarimetric data obtained on March 15. In the red wing of H_β ($\Delta\lambda = 5$ Å) the polarization net is by a factor ~4 lower than that in the continuum, and in the blue wing ($\Delta\lambda = 5$ Å) $\rho \sim 0.8$ of the mean level in the continuum see Table 1. It is possible to make the following conclusions concerning the comparison of polarimetry across the Doppler broadened emission lines with broad-band polarization data. This conclusion is made for the first time. Nonaxisymmetric profile of polarization net across the emission line is typical for rotational axisymmetric Be stars' envelopes. In this case, the nonaxisymmetric profile of polarization is accompanied by a difference of position angles in each wing, in comparison with that in the continuum (McLean, 1980).

In our case, polarimetry across Doppler broadened H_β line reflects a complicated situation of interaction of the neutron star with the Be star's envelope.

It is highly probable that in the case of AO535 + 26, the X-ray flares occur when the neutron star is near the periaston point of its eccentric orbit. One can imagine a situation when the neutron star located between the normal star and the observer, destroys the nearest part of the Be-star's envelope, thus leading to a non-symmetric structure of the envelope. In this case the preceding part of the envelope would be more disturbed than the approaching one which leads to observed asymmetry between the red and blue wings of the H_β polrized spectrum.

For a short summary, we note that the 1989 March hard X-ray flare of AO535 + 26 was not typical for this object's behaviour for the recent years. It was not accompanied by the optical and IR birghtness decrease, though relatively small light variations have occurred. Prolarization changes, both wideband and H_β, preceding and accompanying the X-ray event, will hopefully serve to better understanding of the structure of accreting matter in Be-neutron star systems.

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