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OPTICAL BEHAVIOUR OF GRO J0422+32 IN DIFFERENT BRIGHTNESS LEVELS

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ABSTRACT. *We hereby present spectroscopic and photometric observations of the Nova Persei 1992 = GRO J0422+32 obtained at the Special Astrophysical Observatory and at the Bologna Observatory. Our observations show that different outbursts are driven by different mechanisms of accretion. We have interpreted the optical activity we observed on an ultrashort time scale as indicative of non-thermal processes in accretion structures around the compact object.*

1. INTRODUCTION

The big energy source GRO J0422+32 was discovered in the X-ray band on August 5, 1992 by Paciesas & Briggs (1992), and optically identified by Castro-Tirado et al. (1992) as a 12^m transient star called Nova Persei 1992. The X-ray spectrum presented a soft component and a hard tail, as is characteristic of X-ray novae, a subclass of low mass X-ray binaries which probably contain black hole candidates. The X-ray flux showed quasi-periodic oscillations (Kouveliotou et al., 1992; Vikhlinin et al., 1992; Pietsch et al., 1992). The optical light curve displayed second and third secondary maxima approximately 32 and 167 days after the outburst. The average decline rate between the maxima was about 0.01 mag/day. The characteristics of the X-ray and optical light curve make the Nova Per 1992 similar to the V616 Mon and the Nova Mus, supporting the hypothesis that it is a black hole candidate.

In August 1993 the Nova Per 1992 underwent a major new optical burst attaining a luminosity of about 15^m (Castro-Tirado and Ortiz, 1993; Filippenko and Matheson,

1993). The star remained at a high luminosity level for about 15 days, then underwe a very steep decline. In early September, 1993 the star's V magnitude was about (Beskin et al., 1993).

2. OBSERVATIONS

Nova Per 1992 was observed in 1992 and 1993 at the Special Astrophysical Observa tory (SAO) with a TV spectral scanner, UBVR photometer, and hard/software MANI (Multichannel Analysis of Nanoseconds Intensity Alteration) complex mounted on th 6 m (BTA) telescope and with the 1 m telescope equipped with CCD, and at the Bologn Observatory with the fast double-head photometer and the Boller & Chivens 267 grating spectrograph with a CCD sensor, mounted on the 1.5 m telescope.

Considering the spectroscopic and photometric behaviour of the Nova Per 199 during the fading phase from August 1992 to July 1993, we distinguish, somewha arbitrarily, high and low optical states.

2.1 The first optical decline

a) The high optical state. We consider Nova Per 1992 in "high optical state" whe its V magnitude is $\leqslant 15.5$; this happened during the first 6 months after the outburs of August 1992. In this period the spectra of the star showed a blue continuum vari able on time scales of days or hours (Fig. 1) and some weak emission features (H an He).

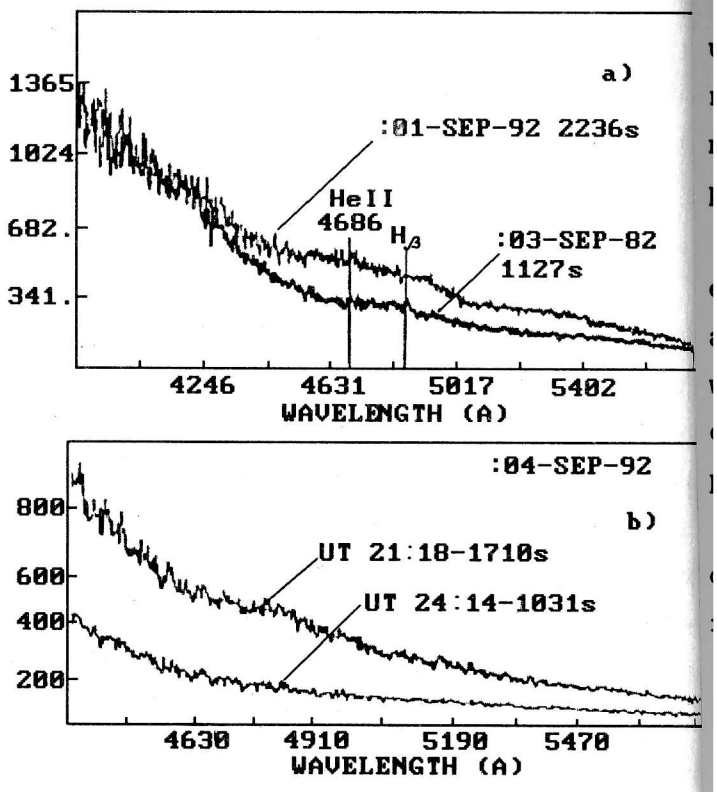

Fig. 1. **a)** *Variability of the continuum and of the emission lines of the Nova Per 1992 on time scale of days. On September 1, 1993* H_β *was probably in absorption, and He II 4686 was not visible; on September 3 both the lines had become clearly seen in emission.*

b) *Variability of the continuum and of the emission lines of the Nova Per 1992 on a time scale of hours on September 4, 1993.*

The luminosity of Nova Per 1992 was irregularly variable in different colour bands (B, V, R) on time scales ranging from 4 ms to 200 s (Fig. 2a). An example of a

short flare is given in Fig. 2b.

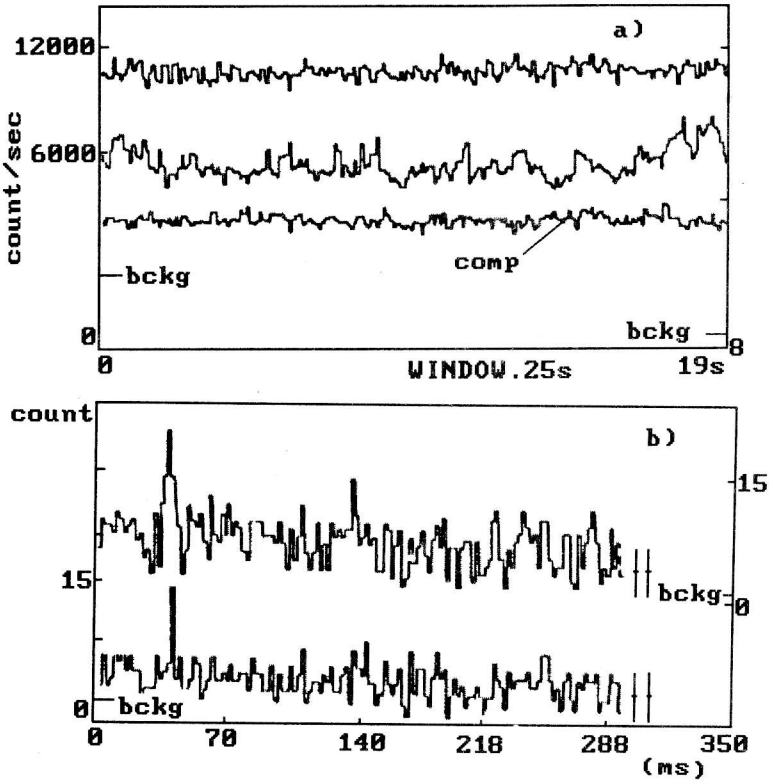

Fig. 2. **a)** *Absence of microvariability of Nova Per 1992 during the low optical state on July 21, 1993 (top). Microvariability of Nova Per 1992 during the high optical state on January 18, 1993 (middle). The behaviour of a constant star of approximately the same magnitude is shown for comparison (bottom). On the left and right scales the photon counts of the Nova and of the comparison star are indicated respectively.*

b) *Flash of the Nova Per 1992 showing a rise time of 4 ms, observed on January 18, 1993 in V light (top) and in B light (bottom).*

The shortest flares show rising times of 4-40 ms, which allows us to establish an upper limit of 10^8 - 10^9 cm on the size of the flares origin regions. In the time range of 100 ns - 1 ms it is highly probable that variability was absent. A preliminary analysis of the observations taken with the double-head photometer shows a flat power spectrum in the range between 5 s and 15 min.

Our double-head photoelectric observations on December 27 and 29, 1992 (Bartolini et al., 1993) confirm the 5-hour periodic variations reported by Kato et al. (1992) and by Chevalier and Ilovaisky (1992). Nevertheless the modulation, whose amplitude was of about 0.35^m, can be fairly well represented by a two-maxima sinusoidal curve with a doubled period. On February 13, 1993 the periodic variation was still present but the amplitude decreased to 0.08^m.

b) The low optical state. During the "low optical state" (V > 15.5) Nova Per 1992 does not show any significant variability (Fig. 2a), at least in the time interval from 100 ns to 200 s we have analyzed thus far.

A sudden passage from the high to low state occurred in 20 s on December 29, 1992 (Bartolini et al., 1993).

2.2 The outburst of August 1993

In the second week of August 1993 Nova Per 1992 underwent a second big optical

outburst, the characteristics of which were quite different from those of Augus 1992: the 1993 maximum presented a flat shape that lasted at least 15 days, followe by a rapid drop at a rate of not less than 0.16 mag/day.

We observed Nova Per 1992 with the TV scanner of the SAO 6 m telescope on Septem ber 11 and 12, 1993 when the V magnitude of the star was fainter than 18. The spectr (Fig. 3a,b) showed some emission features including H_α, H_β and probably HeI 5876 (but not HeII 4686) on a red continuum. There were indications that He I 5876 (and perhaps H_α) was variable on a time scale of hours.

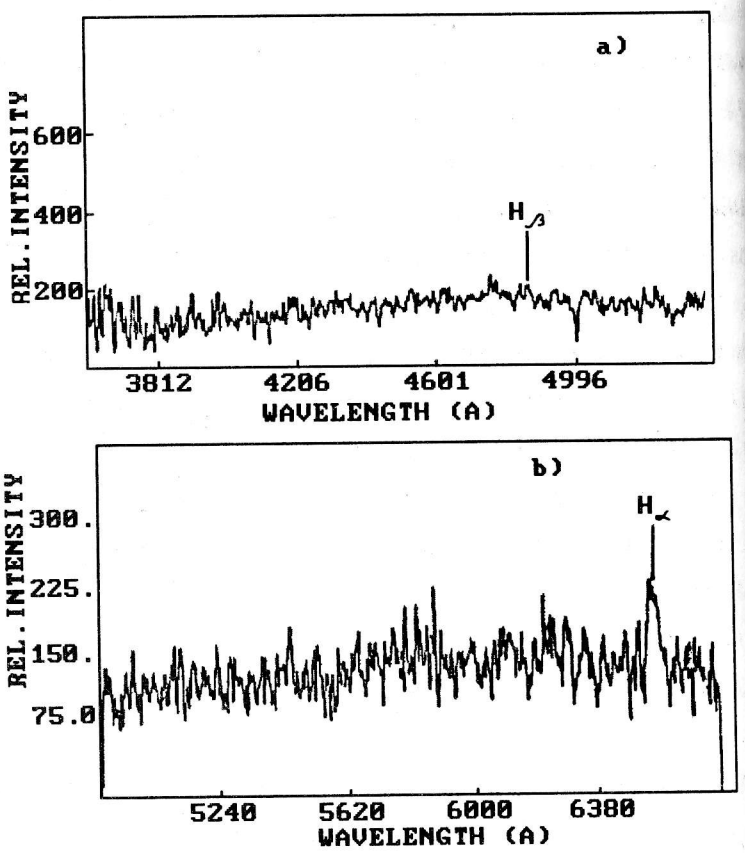

Fig. 3. **a)** *Spectrum of Nova Per 1992 in the blue region taken with the SAO 6 m telescope on September 11, 1993.* H_β *in emission is probably present.*
b) *Spectrum of Nova Per 1992 in the red region taken with the SAO 6 m telescope on September 12, 1993.* H_α *in emission is evident. He I 5876 is also in emission.*

3. CONCLUSIONS

The ultrashort optical flares we detected in the high state can be linked to th dimensions of the origin regions (which we found to be the typical ones of accretio structures) and to the emission mechanism of the radiation. Assuming a distance t the object larger than 2 kpc, the flares are indicative of a brightness temperatur $T_b > 10^8 - 10^9$ K (Bartolini et al., 1993), which proves the existence of a non-therma mechanism for the generation of the photons. We believe that the microvariability i the high state could be the result of a fragmentation in the accreting structure where the non-thermal optical emission is generated. This fragmentation is absent i the low state. It can also be noted that a variability on a time interval 2 ms - 1 min was observed in the X-ray band near the X-ray maximum of Nova Cyg 1989 GS 2023+338 (Kitamoto et al., 1989).

It has recently been proposed (Chen et al., 1993) that disk instability and mass transfer instability could be responsible, respectively, for the main and the follow-

ing bursts in the X-ray novae which are black holes candidates. This hypothesis is supported by the recent behaviour of Nova Per 1992. As we have already emphasized, the outburst of August 1993 is completely different from the one on August 1992.

Moreover, the spectra we acquired approximately one month after the onset of the optical outburst of August 1993 are very different from those we obtained one month after the optical outburst of August 1992. We conclude that there are strong indications of a different mechanism for the two big outbursts which occurred one year apart in Nova Per 1992. Knowledge of the behaviour of the source in other energy bands is crucial for checking the nature of these mechanisms.

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