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Spectroscopic study of GRO J1655-40: the outburst and the decline*

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Abstract. We have analysed 53 optical spectra (40 taken during the outburst peak and 13 during the decline) of the Soft X–ray Transient GRO J1655-40 (=X–Ray Nova Scorpii 1994). The H_α flux during outburst shows a periodicity of 1.3 days, which is almost exactly one half of the one obtained by Bailyn et al. (1995b) from radial velocity variations. A possible explanation for this behaviour is provided. We also notice that the spectral emission features shrink or turn into absorption lines with an emission core during the decline. This is typical of Soft X–ray Transients and suggests that an expansion of the disk takes place after the outburst peak phase.

Key words: accretion disks – stars: individual (GRO J1655-40, X–ray Nova Sco 1994) – X–rays: stars

1. Introduction

GRO J1655-40 (=X–Ray Nova Sco 1994) was discovered as a new X–ray source on July 27, 1994 with the BATSE instrument mounted on the Compton Gamma–Ray Observatory satellite (Zhang et al. 1994, Harmon et al. 1995a). The analysis of the X–ray spectrum made by Wilson et al. (1994) allowed the classification of the nova as a Soft X–ray Transient (SXT) and a black–hole candidate.

The optical counterpart was found by Bailyn et al. (1995a) as a 14.2 V–magnitude star, with strong Balmer, He I, He II and N III emission lines superimposed on a rather reddened continuum. Radio observations (Hjellming & Rupen 1995, Tingay et al. 1995) have shown radio jets, similar to those exhibited by active galactic nuclei, though on a much smaller scale. This is a unique feature for a SXT. Some parameters of the binary system, such as the distance and the inclination ($\approx$ 3.2 kpc and $\approx$ 85° respectively, according to Hjellming & Rupen 1995), were derived by studying the structure of the radio jets.

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* Based on observations obtained at the European Southern Observatory, La Silla, Chile.

A high inclination for the system is also suggested by Bailyn et al. (1995a), who probably observed an eclipse in both the V and the $(V - I)$ lightcurves. During the six months following the first outburst the object experienced two additional strong X-ray brightenings (Harmon et al. 1995a), thus showing an outstanding behaviour among the other SXTs, which generally present only one primary maximum. The radio lightcurve also presented secondary maxima in correspondence of the X–ray outbursts, indicating a clear correlation between the matter accretion onto the compact object and the jet phenomenon (Harmon et al. 1995a).

Further X–ray outbursts have been detected during 1995 (Harmon et al. 1995b, Alexandrovich et al. 1995, Harmon et al. 1995c, Wilson et al. 1995, Harmon et al. 1995d, Harmon et al. 1995e, Sazonov & Sunyaev 1995a), the last one peaking on August 17, 1995 (Sazonov & Sunyaev 1995b, Zhang et al. 1995). This indicates that more than one year after the beginning of the high–energy activity, the nova was still well far from quiescence. This activity is also detectable in the optical bands (Orosz et al. 1995).

Furthermore, Zhang et al. (1995) noticed that the X–ray maxima seem to recur with a periodicity of $\sim$ 120 days.

A restart of the X–ray activity has been noticed in the late April 1996: Remillard et al. (1996) reported that the object has reached an X–ray flux of 1.5 Crab, comparable with those of the preceding X–ray maxima.

Spectrophotometric observations in the optical bands have been performed by Bailyn et al. (1995b) during the period March 18 – May 3, 1995, while the source was in a low state of activity ($<V>$ = 16.4). They found a spectroscopical periodicity of 2.601 ± 0.007 days and a mass function of $3.16 \pm 0.15\ M_\odot$. The secondary star is likely to be a yellow subgiant of spectral type F5 IV. Their photometric data seem instead to indicate that the periodicity of the lightcurve is slightly longer, thus suggesting some sort of activity of the disk (i.e. hot spots or superhumps).

Finally, Brandt et al. (1995) found that the γ–velocity of GRO J1655-40 is fairly high (–150 $\pm$ 19 km s^{-1}) compared to the velocities of the other black–hole SXTs, and analysed several scenarios for the genesis of a high–velocity black hole.

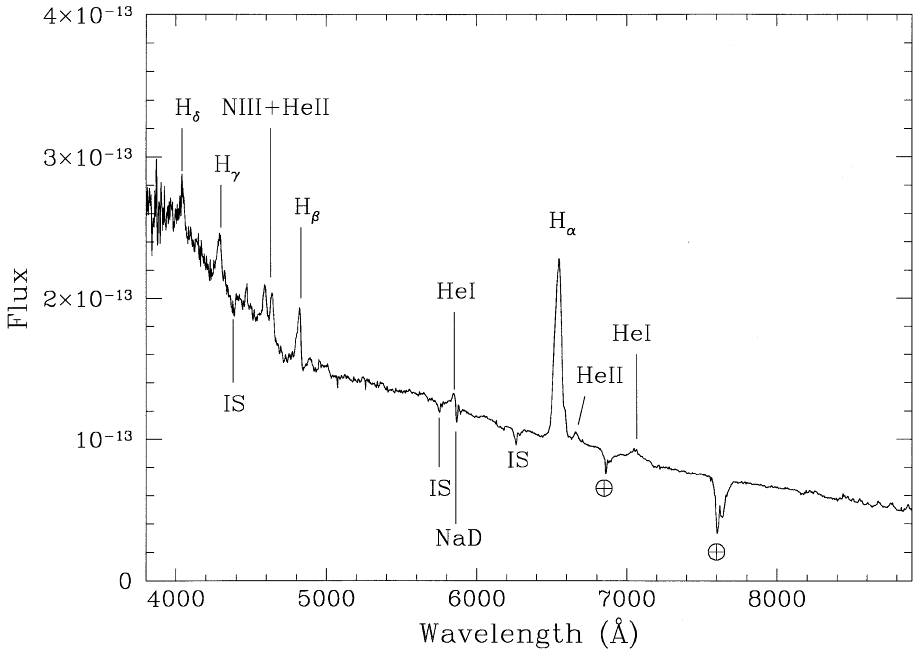

Fig. 1. Mean of the outburst spectra taken during the August 1994 run. The main features are indicated and described in the text. We used $E(B-V)$ = 1.13 to correct for reddening. Fluxes are in ergs cm^{-2} s^{-1}

Table 1. The journal of the observations. The upper part of the Table lists the spectroscopic data, while the single photometric observation is reported in the lower part

Date	Telescope	Filter or passband	Number of frames	Exp. times (minutes)
Spectra				
Aug. 12, 1994	1.5m	$Gr4$	2	20,45
Aug. 13, 1994	1.5m	$Gr4$	5	15
Aug. 14, 1994	1.5m	$Gr4$	18	12
Aug. 15, 1994	1.5m	$Gr4$	15	12
Mar. 3, 1995	NTT	#2, $Gr7$	1,3	10,20,40
Mar. 4, 1995	NTT	$Gr7$	9	10,15,20,25
Imaging				
Mar. 3, 1995	NTT	R	1	1

Table 2. Mean equivalent widths (EWs) of emission lines during the outburst and the decline spectra of GRO J1655-40. The H_β line of the decline seems to be formed by a shallow absorption (abs) plus a narrow emission core

Emission line	Outburst EW	Decline EW
H_α	68.4	6.45
H_β	7.39	1.16 (9.28 abs)
H_γ	7.28	—
H_δ	5.07	—
He I λ7066	4.65	—
He I λ5876	3.76	0.73
He II λ6678	1.98	0.65
He II λ4686	5.30	3.85
N III λ4640	5.88	4.59

In this paper we present the spectroscopic observations made partly during the early outburst phases and partly during the decline. In Sect. 2 we briefly illustrate the instruments and the methods used for the data acquisition. In Sect. 3 we describe the data reduction, we analyse the main spectroscopic features of the outburst and the decline and look for periodic behaviours. In Sect. 4 we discuss the results and depict a possible scenario for the object.

2. The observations

The spectra were taken at La Silla during two different runs (see the journal of the observations of Table 1).

During the first run the source was monitored soon after the first X-ray outburst, from August 12 to 15, 1994, using the 1.5m ESO telescope, equipped with the Boller & Chivens spectrograph and CCD (ESO #24, Ford 2048L, pixels size = 15 μm). We collected 40 grating spectra (3500–9400 Å), with a resolution of $\approx$ 2.8 Å/pixel.

The second run was performed 7 months later, on March 3–4, 1995, shortly after a period of strong X–ray activity (Alexandrovich et al. 1995). We used the NTT telescope and the EMMI with the Tektronix CCD TK2048EB (ESO #36, pixel size = 24 μm). 13 spectra were obtained: one in the RILD mode with the grism #2 (3900–9600 Å), the others in the REMD mode with the grating 7 (with a spectral range of 1180 Å) centered at about 6000 Å. The resolutions were 2.8 Å/pixel and 0.65 Å/pixel, respectively.

A single R image of GRO J1655-40 was obtained on March 3, 1995 (see Table 1) and showed the star at R = 14.33 $\pm$ 0.03.

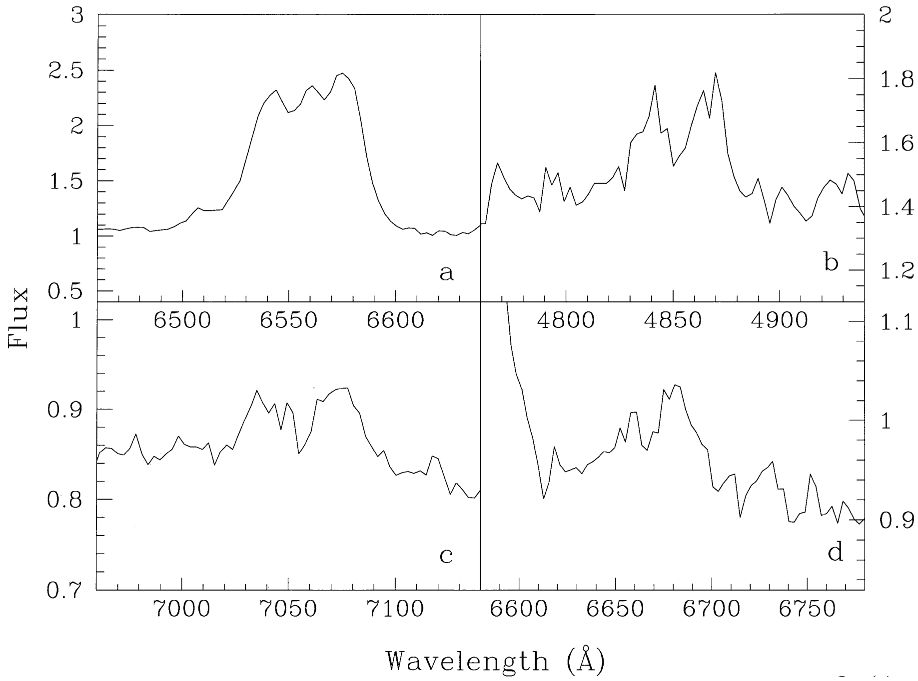

Fig. 2a–d. Profiles of **a** H_α, **b** H_β, **c** He II λ6678 and **d** He I λ7066 emissions during outburst maximum. Fluxes are in units of 10^{-13} ergs cm^{-2} s^{-1}. Correction for interstellar reddening has been applied

3. Data reduction and analysis

All the spectra have been corrected with standard procedures for bias and flat field and processed with the IRAF package. Wavelength calibrations were made by means of He–Ar lamps, and flux calibrations were performed using the spectroscopic standards LTT 7379, LTT 377 and LTT 9239 for the spectra of the August 1994 run, and LTT 4364 for those of the March 1995 run.

The equivalent widths of the interstellar 5980 Å NaD doublet and the 6613 Å line measured on the higher resolution spectra, by fitting gaussian profiles, result in 2.26 Å and 0.27 Å, respectively. Using the relations between the equivalent widths of these lines and the color excess given by Herbig (1975), for the 6613 Å absorption, and by Della Valle & Dürbeck (1993), for the NaD doublet, we obtain a $(B-V)$ color excess of 0.97 and 1.30 mag, respectively. A mean value of $E(B-V) = 1.13$ is then adopted, which is also in good agreement with the estimate given by Bailyn et al. (1995a).

The mean of the 40 outburst spectra is displayed in Fig. 1. The predominant H_α emission and the fainter H_β present structured profiles (double– or triple–peaked; Fig. 2a,b) while rather noisy H_γ and H_δ components are visible. The emissions of He II λ6678, He I λ7066 (Fig. 2c,d, respectively), and possibly He I λ5876 also show double–peaked profiles. The N III λ4640 and the He II λ4686 emissions appear weakly blended.

The single lower resolution spectrum and the mean of the 12 higher resolution spectra of the nova during the decline are presented in Fig. 3a,b, respectively. Dereddening has been applied to the spectra of Figs. 1, 2a,b,c,d and 3a, using the prescription of Cardelli et al. (1989). The higher resolution mean spectrum of the decline was obtained under non photometric conditions that

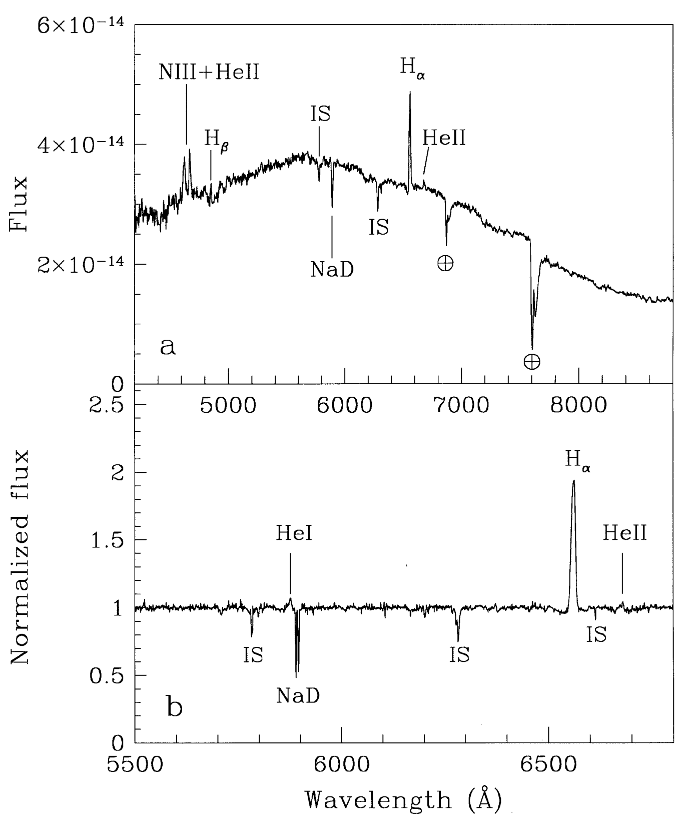

Fig. 3. a Low–resolution spectrum of GRO J1655-40 taken on March 3, 1995. **b** Normalized high–resolution spectrum taken on March 3–4, 1995 (mean of 13 spectra). The main features are indicated and described in the text. The fluxes given in the upper panel are in ergs cm^{-2} s^{-1} and are corrected for interstellar reddening

do not allow reliable spectrophotometric measurements. The spectrum with the normalized continuum is shown in Fig. 3b.

Table 2 reports the equivalent widths of the main emission lines for the outburst and the decline mean spectra.

The fluxes of the continuum and of the emission lines of the outburst spectra of the nova show fluctuations up to 50% of their mean values. We have looked for periodic behaviour by means of the Discrete Fourier Transform (DFT) algorithm and the CLEAN approach (Roberts et al. 1987).

We have performed a spline fit of the continuum between 4000 and 9000 Å and studied the variations of its integrated flux. The DFT spectrum of the integrated flux of the continuum is given in Fig. 4a. A main peak at 0.582623 days with side aliases at 0.366797 and 1.415528 days is suggested and confirmed by the CLEAN procedure.

The DFT of the fluxes of H_α shown in Fig. 4b presents a main peak at 1.296807 days. This period is also suggested by the CLEAN algorithm and by the Sterken's best–fit method (1977). We note that this value is almost exactly half the period of the radial velocity curve found by Bailyn et al. (1995b). This peak coincides within the errors with the 1.42 days alias of the DFT of the continuum. Other relevant aliases fall at 4.24 days and 0.56 days.

The fluxes of the other emission lines show rather noisy power spectra. Main peaks are found at 0.270 days for H_β and He I λ7066, and at 0.213 days for He II λ6678. We note however that all these peaks belong also to the sequence of aliases of the DFTs of the continuum and of the H_α fluxes (Figs. 4a and 4b, respectively).

The DFTs of the equivalent widths of all the emission lines, including H_α, do not suggest any periodicity, being dominated by the pure data sampling.

On August 17 1994, Bailyn et al. (1995a) observed an eclipse-like lightcurve of GRO J1655-40. According to the ephemeris given by Bailyn et al. (1995b), this event could correspond to the eclipse of the secondary star by the disk, although the behaviour of the $(V - I)$ colors observed by Bailyn et al. (1995a) seems to indicate lower temperatures inside the eclipse. The last three spectra of our run of August 14 should then fall at the beginning of a secondary eclipse. We can in fact observe that the fluxes of the continuum and the emission lines of these three spectra show a sudden decrease. These data points will be represented in our folded lightcurves with open circles.

We then tried harmonic analysis of our data after the exclusion of the eclipse points. We observe that the DFTs of the fluxes of H_α and of the continuum are now more similar, as shown in Fig. 5a,b, respectively. A most probable modulation at 1.3 days is indicated, although, in this case, the 'odd' sequence of the 1-day aliases of the DFT of H_α results stronger than the 'even' sequence. This effect is however mainly due to the sampling. In fact, if we subtract from the H_α fluxes the 1.3 days modulation, we obtain a pure noise DFT.

The DFTs of He I and He II emissions are similar to those obtained using the full data sets, with peaks that still belong to the sequence of the aliases found for H_α and the continuum. In this case, periods longer and shorter than the 1.3 days modulation would be suggested by He I and He II, respectively. If we subtract a 1.3 days cosine with appropriate amplitude and phase from the He I and He II data sets, we obtain DFTs with lower level peaks at ≈ 0.45 and ≈ 0.15 days, respectively, which still are aliases of the 1.3 days period. The He II/He I flux ratios, instead, show no signal at all above the noise level, thus suggesting quite similar behaviours for these two lines.

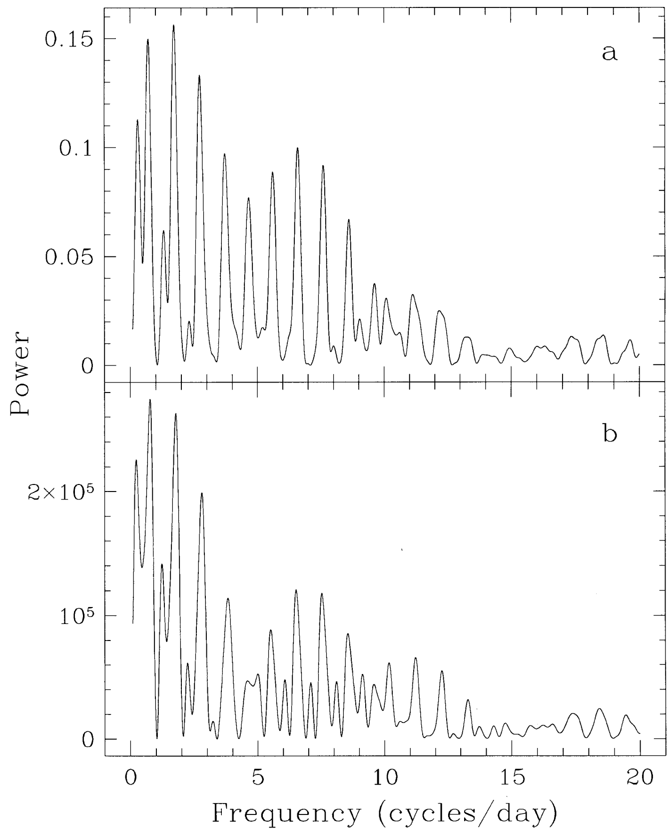

Fig. 4a and b. DFTs of **a** 4000–9000Å continuum and **b** H_α emission line fluxes (not corrected for interstellar reddening) during the August 1994 run. The peak of the peaks falls at 0.583 days (with a 1–day alias at 1.415 days) for the continuum, and at 1.297 days for H_α. The DFTs of H_β, He I λ7066 and He II λ6678 show the same sequence of aliases of the continuum, though the main peaks now fall at higher frequencies (see text)

We finally note that the equivalent widths of all emission lines still show no significant feature.

The lightcurves of the integrated continua folded with the 1.3 and the 2.6 days periods, the former being the main modulation found for H_α, are shown in Fig. 6a,b, respectively. The fluxes of H_α folded with the 1.3 and 2.6 days periods are given in Fig. 7a,b, respectively.

Multi–varied analysis has been also performed to look for correlations between the measured quantities. The eclipse data points have been excluded. The linear correlation coefficients are reported in Table 3, as well as their corresponding probability to be higher in the case of a random sample of observations taken from an uncorrelated parent population (see Bevington 1969, appendix C–3).

Table 3. Correlation coefficients obtained with multi–varied analysis performed over equivalent widths and fluxes of the most prominent emission lines and of the continuum of the outburst spectra and (between parentheses) their corresponding probability to be higher in the case of a random sample of observations taken from an uncorrelated parent population. We excluded the eclipse points from these computations

	F_{cont}	F_{H_α}	F_{H_β}	F_{HeI}	F_{HeII}	EW_{H_α}	EW_{H_β}	EW_{HeI}	EW_{HeII}
F_{cont}	—	0.82	0.46	0.21	0.28	-0.23	-0.22	0.33	-0.24
		(0%)	(0.4%)	(20%)	(10%)	(18%)	(20%)	(5%)	(15%)
F_{H_α}	0.82	—	0.38	0.16	0.30	-0.10	-0.12	0.18	-0.09
	(0%)		(2%)	(35%)	(8%)	(70%)	(45%)	(30%)	(80%)
F_{H_β}	0.46	0.38	—	0.50	0.44	-0.14	0.25	0.15	0.09
	(0.4%)	(2%)		(0.2%)	(0.5%)	(40%)	(15%)	(40%)	(80%)
F_{HeI}	0.21	0.16	0.50	—	0.41	-0.16	0.00	0.79	0.19
	(20%)	(35%)	(0.2%)		(1%)	(35%)	(100%)	(0%)	(25%)
F_{HeII}	0.28	0.30	0.44	0.41	—	0.07	0.06	0.15	0.57
	(10%)	(8%)	(0.5%)	(1%)		(85%)	(90%)	(40%)	(0%)
EW_{H_α}	-0.23	-0.10	-0.14	-0.16	0.07	—	0.04	-0.05	0.08
	(18%)	(70%)	(40%)	(35%)	(85%)		(100%)	(95%)	(80%)
EW_{H_β}	-0.22	-0.12	0.25	0.00	0.06	0.04	—	0.06	0.34
	(20%)	(45%)	(15%)	(100%)	(90%)	(100%)		(90%)	(4%)
EW_{HeI}	0.33	0.18	0.15	0.79	0.15	-0.05	0.06	—	0.33
	(5%)	(30%)	(40%)	(0%)	(40%)	(95%)	(90%)		(5%)
EW_{HeII}	-0.24	-0.09	0.09	0.19	0.57	0.08	0.34	0.33	—
	(15%)	(80%)	(80%)	(25%)	(0%)	(80%)	(4%)	(5%)	

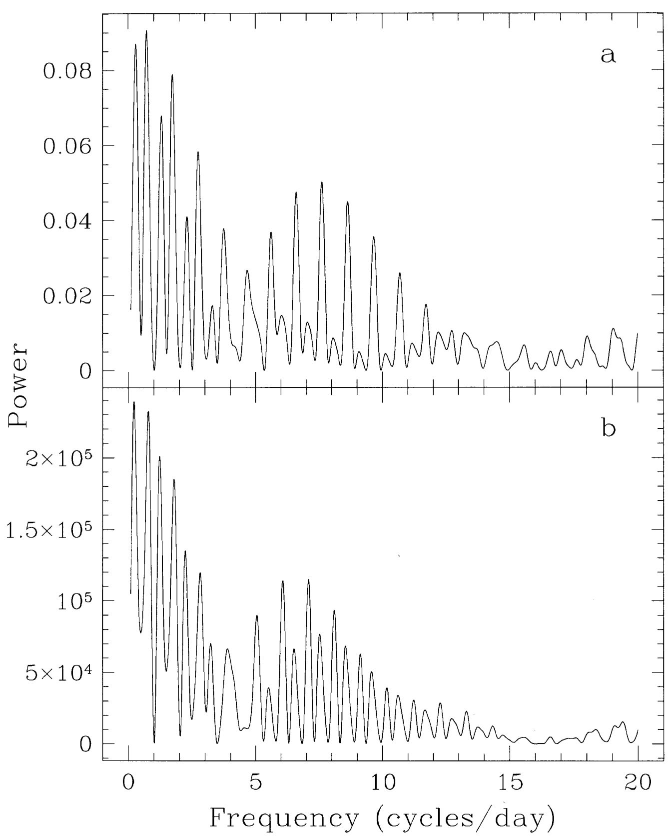

Fig. 5a and b. The same as Fig. 4 but without taking into account the eclipse points. The sequence of aliases of the continuum and the H_α fluxes are now very similar. The main peak of the DFT of the continuum fluxes falls at 1.297 days

The analysis suggests strong correlation between H_α and the continuum fluxes. Both these quantities appear only weakly correlated with all the other emission lines, H_β included. Almost no correlation is found between the fluxes and the equivalent widths of the lines, with the exception of He I and He II. The correlation coefficients between the equivalent widths are also quite poor.

No noticeable result came out from the analysis of the variations of the peak–to–peak separations and of the V/R ratios.

4. Discussion

Few SXTs, like GRO J1655-40, have been systematically monitored throughout the whole decline. The presence of X–ray minioutbursts during the decline (Zhang et al. 1995) with a recurrence time of 120 days reminds the lightcurve of the other SXT V518 Per (=GRO J0422+32), which presented the same periodicity of secondary outbursts, though this object appeared more active in the optical than in the X–ray (Chevalier & Ilovaisky 1995).

The binary nature of GRO J1655-40 was assessed by the photometric study of Bailyn et al. (1995a). The peculiarity of this object, amongst other SXTs, is the presence of structured radio jets which however supported the hypothesis of mass accretion onto a collapsed primary inside a highly inclined binary system (Hjellming & Rupen 1995, Tingay et al. 1995).

4.1. Spectral evolution of the outburst

The decrease of the flux of the continuum during the decline (Fig. 3a) is consistent with the observed difference of ≈ 2 mag

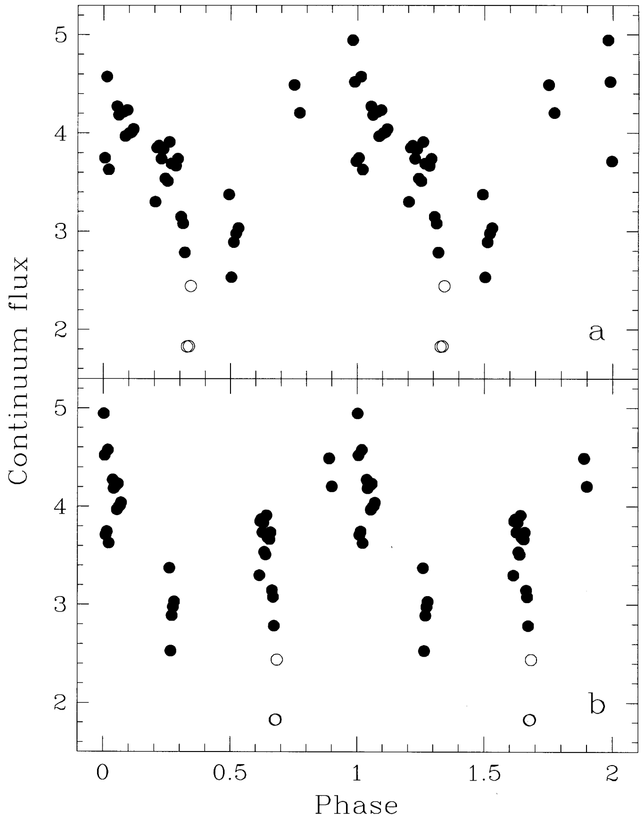

Fig. 6a and b. Lightcurve of the continuum flux (4000–9000 Å) at light maximum folded with **a** 1.3–day and **b** Bailyn et al.'s (1995b) 2.6–day periods. Phases are arbitrarily referred to JD=0.00. Fluxes are in units of 10^{-11} ergs cm^{-2} s^{-1} and are not corrected for interstellar reddening. Open circles refer to a possible beginning of an eclipse

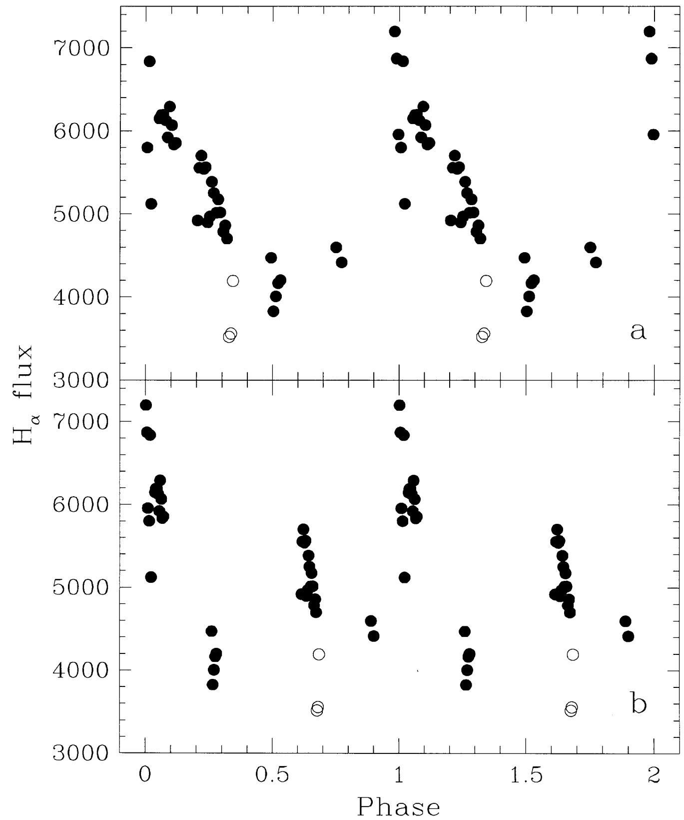

Fig. 7a and b. Lightcurve of the H_α flux during maximum folded with **a** our 1.3–day and **b** Bailyn et al.'s (1995b) 2.6–day periods. Phases are arbitrarily referred to JD=0.00. Fluxes, in units of 10^{-16} ergs cm^{-2} s^{-1}, are not corrected for interstellar reddening. Open circles refer to a possible beginning of an eclipse

between the outburst and the March–April 1995 V luminosities of the star (see Bailyn et al. 1995a, 1995b). The spectrum of Fig. 3a was obtained when the star was about one magnitude above its light minimum at $\sim$ 17.3 mag (Bailyn et al. 1995a). It shows a solar–like energy distribution which would then appear slightly cooler than that of the intermediate F–type suggested by Bailyn et al. (1995b). This could however be due to inaccurate flux calibration of our spectrum.

During the decline, the intensity of the H_α emission has faded by a factor $\approx$ 25, while the flux of the integrated continuum between 5500 and 6750 Å has lowered only by a factor $\approx 5-6$. Table 2 shows that an analogous decrease of the equivalent width is presented also by the H_β emission, while smaller changes are observed in the emissions of He II λ6678, N III λ4640, He II λ4686, and He I λ5876. This fact indicates that the line emitting region of GRO J1655-40 shrinks more steeply than that of outbursting Dwarf Novae (DNe).

This represents a basic difference between the behaviours of SXTs and DNe. In DNe, Balmer emission lines appear weaker at light maxima, well inside shallow absorption components, and as the object evolves towards light minimum, the absorption wings disappear and the emission components strengthen considerably. The opposite trend observed in SXTs (e.g. Bailyn & Orosz 1995 for X–ray Nova Velorum 1993; Callanan et al. 1995 for V518 Per) supports the idea that during their outbursts a strong increase of the mass transfer rate from the secondary, and not only through the disk, is produced, most probably by the X–ray heating of the secondary by the primary. The bulk of the line emission region could then be placed in the gas stream between the two components.

We also note that the FWZI of H_α is $\sim$ 120 Å at light peak, and only $\sim$ 30 Å during the decline, when profiles are no longer double peaked and resemble more those of Nova-Like objects. This indicates the presence in the line–emitting region of large velocity fields (up to about $\pm$ 2700 km s^{-1}) near the light peak, and of lower velocities (up to about $\pm$ 700 km s^{-1}) at light minimum. This explains why we can see the $\sim$ 100 Å wide absorption around the H_α and the H_β emissions only in the spectra of the decline, when the emission components are narrower. We may note that the velocity fields observed in SXTs are generally larger then those observed in DNe, thus supporting the existence in the former ones of rather massive primaries.

The mean peak–to–peak half separation of the H_α emission profile at light maximum might indicate keplerian velocities of $\approx$ 800 km s^{-1}. The FWHM of the single–peaked H_α of the decline spectra is instead $\sim$ 17 Å, suggesting rotational velocities of ≈ 400 km s^{-1}. If we assume a 5.4 $M_\odot$ primary (Bailyn et al. 1995b), and a 90° orbital inclination, the radius of the accretion disk in outburst is $\sim 1.6\,R_\odot$, that is only ~ 0.25 times the Roche lobe radius of the primary, but it reaches the radius of the Roche lobe during the decline. This behaviour is once again opposite to that displayed by outbursting DNe, whose accretion disks, as a consequence of the disk instability mechanism, present larger radii at light maximum than at quiescence. In SXTs, instead, in addition to the disk instability phenomenon, we observe a strong increase of the mass transfer rate from the X–ray heated secondary. Such a burst of low angular momentum material from the secondary would then cause the shrinking of the disk.

4.2. Shorter term flux modulations

Since our data set spans only over 4 nights, we are unable to properly sample the orbital period of 2.6 days found by Bailyn et al. (1995b). Fourier analysis of the fluxes of the main emission features and of the continuum give rather noisy power spectra. Both the fluxes of H_α and the continuum appear to be modulated with a period of 1.297 days, which, within our uncertainties, can be interpreted as being half Bailyn et al.'s (1995b) spectroscopic period. The DFTs of the fluxes of the other emission lines suggest different main peaks, which are however aliases of the 1.3 days peak.

Actually, Table 3 shows strong correlations between the fluxes of H_α and those of the continuum and only weaker correlations with the other emission lines. We also find that the fluxes of the lines are poorly correlated with the equivalent widths, with perhaps the exception of He I and He II.

The scarcity of the data, the sampling effects due to the poor coverage of the suggested orbital period, the presence of strong flickering, interpreted by Bailyn et al. (1995b) as due to disk effects, make difficult any detailed analysis of short–term modulations.

4.3. The model

As already pointed out, the behaviour of GRO J1655-40 during the outburst is, like other SXTs, opposite to that of DNe. In fact, during the peak of the outburst the accretion disk seems to be powered by a stronger flux of material from the secondary. Since the flow is formed by matter with low angular momentum, the disk will tend to have smaller radius and higher density and temperature during outburst than at quiescence. This explains the larger width of the emission lines observed at light maximum, when higher keplerian velocities of the outer region of the disk are expected.

The detection of half the orbital period in H_α and the continuum might suggest that similar physical conditions can be observed from two opposite sides of the close binary system. The two equivalent sides of the system might correspond to the two stars being in quadrature with respect to the observer. The maximum flux of the emission lines (mainly H_α) might then be produced in the gas stream and the splash region, or the hot spot, placed on the outer edge of the disk. We however note that: i) the half orbital period modulation is observed also in the continuum while almost no modulation is observed in the equivalent widths of all the emission lines; ii) no periodic modulation is seen in He II/He I flux ratios. This means that: i) the observed variations throughout the orbital cycle are mainly due to geometrical reasons and not only to changes in the volume of the line emitting region; ii) no modulation of the temperature of the line emitting region is observed. This might be explained by an asymmetry of the disk shape or by the presence of some vertically extended structure on the disk itself corotating with the binary system.

Actually, the splash region created by the stream impacting the outer edge of the disk might result in a quite extended optically thick curtain of gas. This curtain should then be heated by the UV and X–ray flux from the central object and produce eclipses. Such a structure might be visible from two opposite directions.

Moreover, an optically thick veil of gas might perhaps explain the shape of the eclipse lightcurve of GRO J1655-40 (Fig. 1 of Bailyn et al. 1995b). This figure in fact shows that: i) primary and secondary minima are equidistant; ii) the profile of the main eclipse is asymmetric, the decline being less steep than the rise; iii) the width of the main eclipse is unusually large, the decline starting at $\sim 0.35\times P_{\rm orb}$ before the minimum, while the eclipse ends at $\sim 0.25\times P_{\rm orb}$ after the minimum. The splashed gas could then contribute to the declining part of the eclipse lightcurve.

A large width of the main eclipse could be also explained by hypothesizing that during the decline the outer parts of the accretion disk undergo considerable expansion up to the radius of the Roche lobe.

From the depths of the two eclipse minima we can also infer that, during the decline, the secondary contributes to the total luminosity in the V band for about one half of the disk luminosity.

The splashed material can continue its trajectory flowing above and below the disk and finally fall onto the disk at about the circularization radius. This would produce optically thick blobs of material which orbit at keplerian velocities.

Light modulations with periods shorter than the orbital one have been observed during the high states of activity of the SXTs V404 Cyg (Gotthelf et al. 1992) and GRS 1009-45 (Bailyn & Orosz 1995). In the case of the SXT V2293 Oph they were interpreted by Masetti et al. (1996) as the effect of blobs orbiting in the inner region of the disk. No clear evidence of short–term periodicities was found in GRO J1655-40. We however observe a rather flickered lightcurve. As suggested by Bailyn et al. (1995b), the activity in the disk, such as X–ray heating, hot spots and/or superhumps, might complicate the lightcurve of the X–ray nova producing non–regular fluctuations.

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