THE 2005 OUTBURST OF GRO J1655−40: SPECTRAL EVOLUTION OF THE RISE AS OBSERVED BY *SWIFT*

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ABSTRACT

After nearly a decade of quiescence, the black hole X-ray transient, GRO J1655−40 became active again in 2005 February. This was perfectly timed for the new *Swift* satellite, which has monitored the outburst using all three instruments on board. Therefore we have obtained X-ray spectroscopy for the energy ranges 0.3–10 keV and 15–150 keV, plus optical and ultraviolet photometry (in U, B, V, $UVW1$, $UVM2$ and $UVW2$ filters). We use these data to study the broad-band spectral evolution of the outburst. In particular we find that comparison of the lightcurves at different bands reveals different components to the variability. Preliminary, qualitative study suggests that these component are related to the power-law and disc-blackbody, commonly used to model the X-ray spectra, and therefore reflect the behaviour of the jey/corona and accretion disc respectively.

Key words: Multiwavelength; Black Hole Transients.

1. INTRODUCTION

GRO J1655−40 is a well-known black hole X-ray transient which was discovered in 1994 when it entered a series of hard X-ray outbursts lasting until 1995; a number of the peaks were quasi-simultaneous with radio ejections, some of which showed apparent superluminal motion. An additional outburst took place in 1996 and the source has remained in quiescence since then. The spectral evolution of the 1996 outburst showed a suprising lack of correlation between the soft X-ray and optical lightcurves.

A new outburst was entered in 2005 February. Pointed *Swift* observations were made on 20 occasions between 2005 March 6 and June 23, using the BAT (Burst Alert Telescope), XRT (X-ray Telescope) and UVOT (Ultraviolet/Optical Telescope), supplemented by additional hard X-ray monitoring with the BAT. The source was observed in three of the "canonical" X-ray spectral states typical of black hole X-ray transients – low/hard (LHS), high/soft (HSS) and very high (VHS). The behaviour accompanying each state was reflected in both the lightcurves and the spectra (see Fig. 1).

We note that full details of the results of this study are presented in Brocksopp et al. 2005.

2. RESULTS - X-RAY SPECTRA

X-ray spectra spanning 0.3–150 keV have been obtained in each of the three spectral states in which GRO J1655−40 was observed. They have been modelled using simple power-laws, plus an additional multicolour disc-blackbody for the HSS and VHS data. An iron emission line was present in the LHS spectrum, improving the fit by 4.6σ, but it was not clear whether this iron line was absent during the softer states or just dominated by the blacbody emission. An iron absorption line was present in some of the later HSS and VHS observations (and may have been present in other HSS/VHS observations but was obscured by calibration artefacts). Sample broad-band spectra, one for each spectral state, are plotted in Fig. 1 (left-hand side).

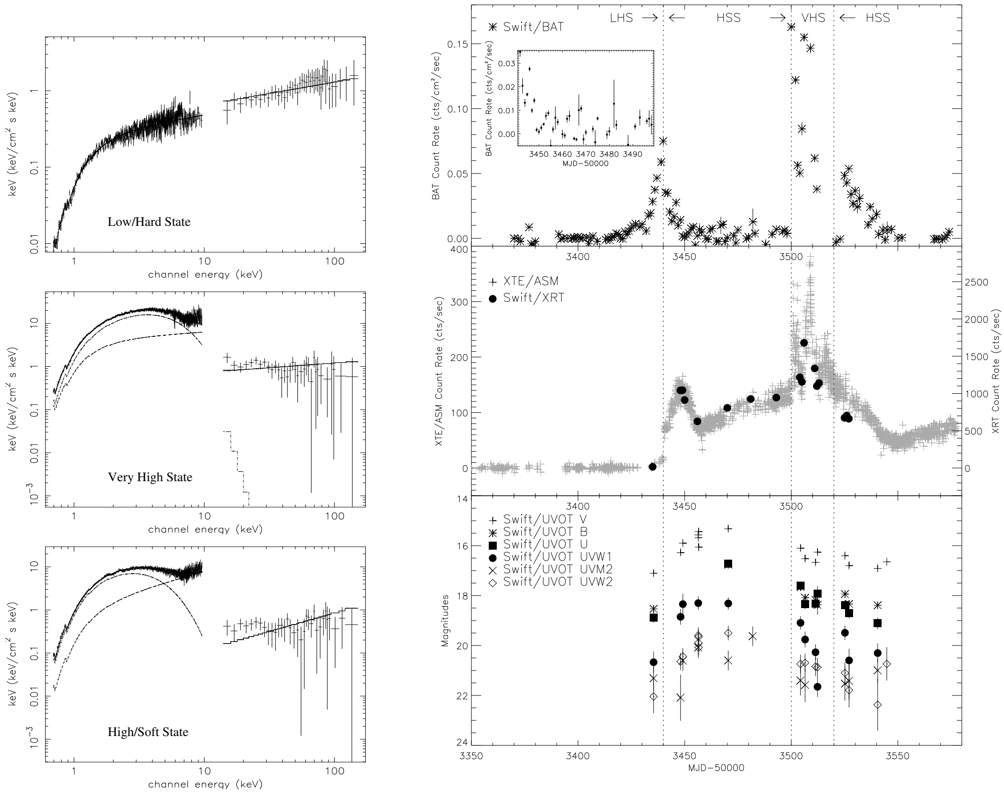

Figure 1. Left: Sample broad-band X-ray spectra plotted in the equivalent of νF_ν-space for each spectral state observed by Swift. We note that the apparent absorption lines around 5–7 keV during the VHS and the apparent excess around 9 keV during the VHS/HSS are calibration artefacts. Right: Plot showing the BAT (top panel), XRT and RXTE/ASM (middle) and UVOT (bottom) lightcurves. The three vertical lines indicate times of LHS–HSS, HSS–VHS and VHS–HSS transitions. The inset plot shows the BAT lightcurve during the HSS – the variability appears to be real.

3. RESULTS - LIGHTCURVES

It is apparent from Fig. 1 (right-hand side) that the three lightcurves are very different from each other. The X-ray plots show a series of peaks, the first of which occurs in the hard X-rays approximately one week before the soft X-rays. Later soft X-ray peaks are delayed only by a day. The period of HSS behaviour is accompanied by a "plateau" phase in the BAT data but a rising phase in the XRT and ASM data. The UVOT data are also increasing in magnitude at this time.

It appears that there are two components to the lightcurves (and such a scenario may also be able to explain the lightcurves of the 1996 outburst; Brocksopp et al . 2005):

- an accretion disc component which brightens smoothly during the rise of the outburst and then drops once the source reached the VHS, providing the UVOT lightcurve and the gradually-rising part of the soft X-ray lightcurve. This is presumably related to the disc blackbody component, typically used when fitting the X-ray spectrum
- a jet and/or corona component which becomes active in soft and hard X-rays at the onset of the outbust; it peaks and decays and then rebrightens suddenly, resulting in the VHS. Again, this is presumably related to the power-law component (either synchrotron or Comptonisation), tyically used when fitting the X-ray spectrum.

REFERENCES

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