XMM-NEWTON OBSERVATIONS OF THE MICROQUASARS GRO J1655-40 AND GRS 1915+105

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ABSTRACT

We present results of a sequence of XMM-Newton observations of the two microqasars GRO J1655-40 and GRS 1915+105. The observations were preformed using the EPCI pn camera in the Burst mode. The observations of GRO J1655-40 in a bright state have made possible a substantial improvement in the calibration of the Burst mode, with determination of the rate dependence of the Charge Transfer Efficiency (CTE). We detect He-like Fe K-shell absorption features in the EPIC-pn spectrum of GRO J1655-40, indicating the presence of a highly ionized absorber, and clear absorption features at 0.71 and 0.72 keV in the RGS spectrum, most probably identified as blueshifted Fe XVIII.

Key words: binaries: close - stars: individual (GRO J1655-40, GRS 1915+105)- X-rays: stars.

1. INTRODUCTION

Microquasars are accreting binary systems in our Galaxy ejecting jets at relativistic velocities. The microquasars GRO J1655-40 and GRS 1915+105 were the two first superluminal sources discovered in our Galaxy. The dynamical mass of the central object, determined to be 7 $M_\odot$ for GRO J1655-40 (Orosz & Bailyn, 1997) and 14 $M_\odot$ for GRS 1915+105 (Greiner et al., 2001), indicates that it is a black hole in both cases. GRO J1655-40 and GRS 1915+105 also share the peculiarity of being thought to contain a maximally spinning black hole (Zhang et al., 1997). ASCA observations of GRO J1655-40 in August 1994 and August 1995 provided the first detection of absorption lines in an accretion powered source (Ueda et al., 1998). The energy of the lines was found to depend on the X-ray intensity, being 6.95 keV (Fe XXVI Kα) at 2.2 Crab, and 6.63 and 7.66 keV (Fe XXV Kα and Kβ) at 0.27-0.57 Crab, revealing the presence of a highly ionized absorber. Similar absorption features were also detected for GRS 1915+105 (Kotani et al., 2000).

After 7 years of quiescence, GRO J1655-40 started a period of activity in February 2005, with RXTE/ASM showing a first outburst between March 10 and April 1, reaching $\sim$2 Crab, followed by a month and a half of increasing X-ray flux and a strong outburst on May 20, when the source reached more than 4 Crab. Here we present the results of four XMM-Newton observations of GRO J1655-40 performed on 27 February (40 ks, TOO), and on 14, 15 and 16 March 2005 (GT, 15 ks each).

2. EPIC-PN CTE CORRECTION

The bright state of GRO J1655-40 at the time of our XMM-Newton observations (almost twice brighter than the Crab, the source used for Burst mode calibration) has shown that the Charge Transfer Efficiency (CTE) in the Burst mode has a stronger rate-dependence than previously modeled. An inaccurate calibration of the EPIC-pn CTE leads to a bad energy determination, which becomes evident in the large residuals around the instrumental Si and Au edges. From our GRO J1655-40 observations, the offset in energy has been found to be rate dependent, being stronger at the center of the PSF, which implies that it can not be directly corrected in the extracted spectrum. We have determined the CTE gain for different rates, selecting and evaluating the energy gain linear factor for spectra extracted from different regions of the

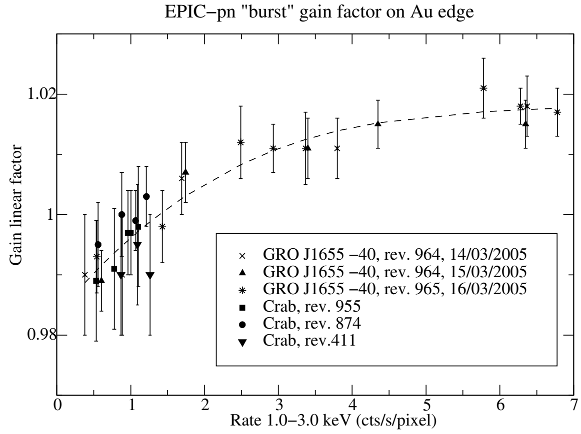

Figure 1. Calibration of the gain linear factor f as a function of rate per pixel r.

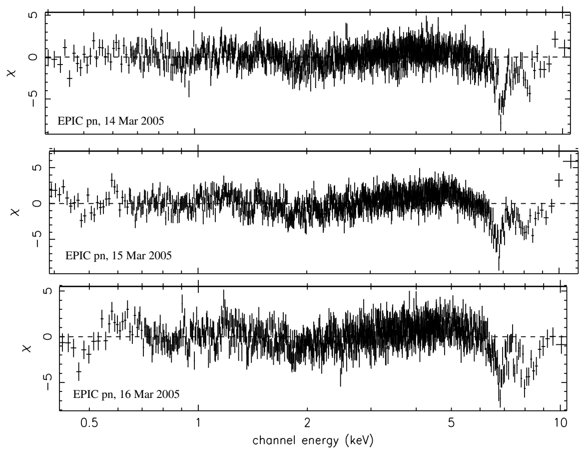

Figure 2. EPIC pn residuals of GRO J1655-40 spectra of our three March 2005 obervations, after fitting an absorbed multi-temperature disk model.

detector (Fig. 1). We have also included the Crab calibration observations to improve the determination of the dependence of the gain linear factor f with the rate per pixel r (cts/s/pixel), which we find can be approximated by $f = 0.98 + 0.015r - 2.2 \times 10^{-3}r^2 + 1.1 \times 10^{-4}r^3$. After correcting the event tables with this linear gain, no more residuals appear around the Au and Si edges.

3. GRO J1655-40 AND GRS 1915+105

For our first XMM-Newton observation of GRO J1655-40, performed on 27 February 2005, some days before the start of the first outburst, a simultaneous RXTE observation is available, which has allowed to determine the X-ray spectrum up to 60 keV. The simultaneous fit to XMM-Newton and RXTE/PCA data shows that the spectrum can be modeled by a multi-temperature accretion disk, plus a power law with index ∼1.5. During our March observations (with exposures of ∼15ks), performed close to the maximum of the first outburst, the spectra of the EPIC pn camera, which was used in the Burst mode, show that the emission is dominated by the multi-temperature accretion disk component, with kT_{in}=1.2-1.3 keV, hotter than the typical temperature observed during the 1996-1997 outburst (Sobczak et al., 1999). We detect two absorption features at 6.8 and 8.0 keV, corresponding to Fe XXV Kα and Kβ absorption lines (Fig. 2). The simultanous RGS data provide the first high resolution spectra of GRO J1655-40, showing clear absorption lines at 0.71 and 0.72 keV (Fig. 3), which could be identified either as OVII at zero velocity, or as a blueshifted Fe XVIII L-shell doublet. The blueshift would indicate in this case an outflowing absorber at 3000 km/s.

The absence of other absorption features in the RGS spectrum is puzzling: if the lines at ∼0.7 keV correspond to OVII K-shell at zero velovity, we would expect to see an even stronger absorption of OVII Kα at ∼0.57 keV that is not present; and if they are Fe XVIII absorption,

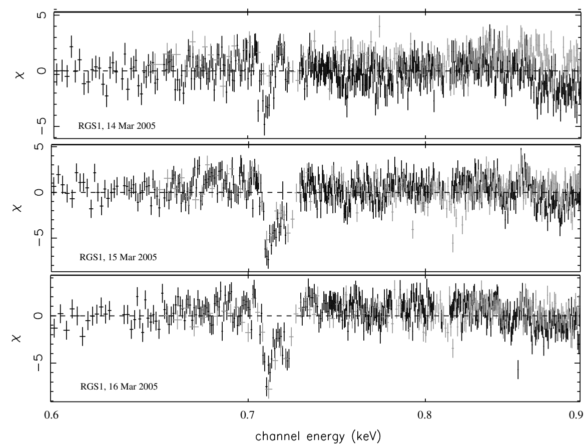

Figure 3. RGS 1 order 1 (black) and 2 (grey) residuals for our March 2005 observations of GRO J1655-40.

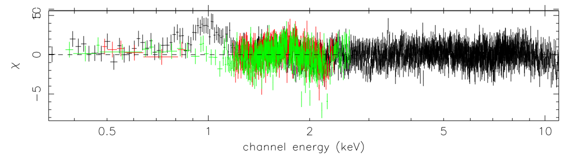

Figure 4. EPIC pn and RGS residuals of the GRS 1915+105 spectrum.

Fe XVII should be also present. In addition, the lack of observable OVIII and the presence of Fe XXV can only be explained by a highly ionized gas, with temperatures higher than $kT \sim 1.7$ keV. But at higher temperatures, Fe XVIII would not be expected to be present, constraining the possible temperature of the absorber to a narrow range, higher than the disk temperature derived from its thermal emission ($kT \sim 1.2 - 1.3$ keV).

XMM-Newton observed GRS 1915+105 on 3 May 2004, with 20 ks exposure time, and the EPIC-pn camera in the Burst mode. The EPIC and RGS spectra can be fitted with an absorbed power law, and no evident absorption features are observed. Since the source was not so bright as GRO J1655-40, no CTE problems are found and no residuals appear around the Si and Au edges. Nevertheless, the best-fit leaves an excess in the EPIC-pn spectrum around 1 keV not observed in the two RGS spectra, which could indicate some calibration problem.

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