THE XMM-NEWTON VIEW OF GRS 1915+105 DURING A PLATEAU

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ABSTRACT

Two XMM-*Newton* observations of the black-hole binary GRS1915+105 were triggered in 2004 (April 17 and 21), during a long "plateau" state of the source. We analyzed the data collected with EPIC-pn in Timing and Burst modes, respectively. No thermal disc emission is required by the data; the spectrum is well fitted by four components: a primary component (either a simple power law or thermal Comptonization models) absorbed by cold matter with abundances different than those of standard ISM; reprocessing from an ionized disc; emission and absorption lines; and a soft X-ray excess around 1 keV. The latter is not confirmed by RGS (which were used in the second observation only); if real, the excess could be due to reflection from optically thin photoionized plasma, in which case it may provide a way to disentangle intrinsic from interstellar absorption.

Key words: Black hole physics – Accretion, accretion disks – X-rays: binaries – X-rays: individuals: GRS 1915+105 .

GRS 1915+105 is a well-known black-hole (BH) binary, also classified as a *superluminal microquasar*, with very peculiar variability properties (for a recent review on this source see Fender & Belloni, 2004). Due to very large obscuration, the spectral type of GRS 1915+105's companion (a K-M III star) was discovered lately, via infrared observations, which also helped to finally determine the mass of the central compact object, which has been constrained to $M_c = 14 \pm 4 M_\odot$ (Greiner et al., 2001).

A XMM-*Newton* ToO observation of GRS 1915+105 was proposed in AO2. The observation was intended to be triggered by the occurrence of a "plateau" state of the source similar to that observed during the *Beppo*SAX 1998 observation, when relativistic Fe lines were observed (Martocchia et al. 2002, 2004); this was necessary also in order to have the source in a less dramatic variability state, and at a lower flux level to minimize technical problems due to instrumental pile-up and telemetry. The observation was triggered in April 2004, divided into two parts: OBS1 (April 17) and OBS2 (April 21; see Martocchia et al. 2005 for details).

We succedeed at both a) observing the source in a well-defined, stable physical/spectral state and b) collecting EPIC-pn useful data, only marginally corrupted by telemetry problems. In both observations the source has been caught in the conventional "C" spectral state / χ variability mode as defined by Belloni et al. (2000; see also Fender & Belloni, 2004). It shows a QPO at $\sim$ 0.6 Hz – i.e. what is expected in "plateau" intervals when the frequency vs. spectral hardness correlation is taken into account – with a possible harmonic signal at 1.2 Hz.

We adopted a power law continuum model, which mimics emission by a hot corona or Comptonized thermal emission e.g. from the jet basis; however, an optically thick reflector is required to account for the smeared edge at $\sim$ 7 keV. The latter component yields evidence of an accretion disk being present, or just optically thick, only at quite large distance from the central compact object, al least in the first observation ($r_i/r_g > 300$ in OBS1, ~ 20 in OBS2). That the disk is truncated, i.e. not present in the innermost part, is suggested also by the non-detection of thermal disk emission.

Several line residuals are superimposed on the modeled continuum (see Fig. 1). Part of these may be due to calibration uncertainties, especially at the energies where changes in the EPIC effective area take place (e.g. 1–3 keV). However, we found clear evidence of ionized iron emission around $\sim$ 7 keV: data are well fitted with two

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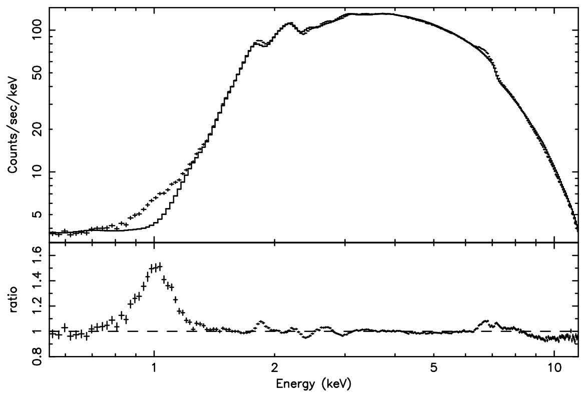

Figure 1. The OBS1 spectrum and data/model ratio, after fitting to a simple power law plus cold absorption model, clearly show the most significant residuals. From: Martocchia et al. (2005).

ionized Fe Kα lines, possibly affected by mild relativistic broadening (being produced far away from the BH event horizon), plus a narrow absorption feature at $\sim$ 6.95 keV.

Finally, we register the puzzling presence of an intense, broad excess around 1 keV in EPIC-pn data; the RGS spectrum does not confirm this, showing instead a fast decline, and no apparent features. Several alternative hypotheses, which can be invoked to explain the RGS–pn discrepancy, are discussed in Martocchia et al. (2005). Assuming (as a still unsubstantied working hypothesis) that the 1 keV excess is real, it could be satisfactorily explained in terms of reflection by an optically thin wind. The excess is indeed well fitted with a power law plus a line, unobscured by material intrinsic to the system. The centroid energy of the gaussian line (~0.97 keV), its width (90 eV), and its EW against the reflected continuum (5.6 keV), point to a blend of Ne K and Fe L lines. The value of the equivalent H column density (as given by the OBS1 best fit, and frozen while fitting OBS2 data) results to be interestingly similar to the value of the obscuration by low Z elements (H, He, C, N, O) at the source core – $N_{\rm H} \sim 1.6 \times 10^{22}$ cm^{-2}: in the disk wind hypothesis, this may therefore be taken as an upper limit to the *interstellar* matter column density. This value matches well with the expected galactic absorption in that direction (Dickey & Lockman 1990).

On the other hand, a significant fraction of the absorber must be *local* to the source. We adopted a variable absorption model (VARABS in XSPEC), assuming neutral matter and grouping the elements on the base of both physical and practical considerations: elements which have probably a common origin, but also elements which are not very abundant (and therefore cannot be easily measured independently one from the other) with very abundant ones (e.g. Co and Ni with Fe). A significant overabundance of the heavier elements with respect to the lighter ones is apparent, which suggests that a significant fraction of the absorber, traced by heavier species, is local to the source. Clearly, the intrinsic absorption may be subject to substantial changes on longer timescales, as already observed with *Rossi*-XTE in correspondence of similar "plateaux" (Belloni et al. 2000).

Line features are less apparent in OBS2 than in OBS1; a 6.4 keV iron emission line is instead marginally found, with an EW of 6±4 eV. The results of OBS2 are consistent with a picture in which the disk is more extended downwards, and more ionized. However, the estimates of the disk radii must be taken with caution, since they are now determined only via the reflection component. Moreover, the OBS2 spectrum at the higher energies can be at least partly affected by Burst-mode calibration problems.

A priori, some of the features in both spectra may be affected by dust halo scattering, too. We cannot check this hypothesis with our data, given the lack of imaging capabilities of timing modes; however, while spectral modelling of such effects is not easy, they would not help explaining the 1 keV excess. In order to try disentagle the different spectral components we used the *rms* vs. *E* method by Ponti et al. (2004). The resulting *rms* is lower than 0.1 all over the energy band, i.e. all spectral components are compatible with being constant, on timescales bigger than $\sim$ 100 s, during the observation.

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