Abstract. We report here the first results of the spectral and timing analysis of our simultaneous INTEGRAL/RXTE observations of GRS 1915+105. The first observation ever performed with INTEGRAL revealed a new class of variability, where changes of luminosity seem driven by changes in the Comptonising medium. The spectro-temporal study of our data taken later, in the steady state, could show the influence of the compact jet in the hard X-rays.

1 Introduction

GRS 1915+105 is one of the most fascinating X-ray sources in our Galaxy. It is the biggest stellar mass black hole (BH) with a mass of $14\pm4.4$ $M_\odot$ (Harlaftis and Greiner 2004), one of the brightest X-ray sources, and a definite source of apparent superluminal ejection (Mirabel & Rodríguez 1994). An up-to-date accurate review of the source can be found in Fender & Belloni (2004).

Since the launch of the INTEGRAL observatory we have monitored the source with dedicated simultaneous INTEGRAL and RXTE pointed observations but also, most of the time, with (nearly) simultaneous observations from the ground in the radio and/or infrared domain. While our second year of monitoring is about to start, we report here the results of the first year of this programme focusing mainly on the data acquired in March-May 2003 during an unprecedented high energy coverage (Fig. 1).
Fig. 1. RXTE/ASM (top), INTEGRAL/ISGRI 20-40 and 40-80 keV (middle), and Ryle 15 GHz (bottom) light curves of GRS 1915+105 covering March–May 2003. The INTEGRAL revolution numbers are indicated. Light grey numbers correspond to the dates where we had simultaneous RXTE pointings.

2 First INTEGRAL observation (revolution 48): a new class of variability

The source is extremely variable in both the soft and hard X-rays (Hannikainen et al. 2003, top left panel of Fig. 2), while the average spectrum is very soft. Our preliminary analysis showed that the source was in a class of variability never observed before (Hannikainen et al. 2003) showing high spikes with quasi periodic period of about 5 minutes, hard rises and soft declines. While a first spectral analysis of an average spectrum was given in Hannikainen et al. (2003), the variability implies a better definition of the good time interval from which to accumulate spectra if one wants to understand the origin of the variations. With RXTE/PCA we produced spectra every 16 s and fitted them with a simple model of multi colour disc black body and a power law, while we accumulated spectra from INTEGRAL/JEM-X and ISGRI from the high level and the low level (Fig. 2, Hannikainen et al. 2005, in prep.). The best fit parameters obtained from the INTEGRAL spectra are $kT_{in} = 1.42 \pm 0.03$ keV and $\Gamma = 3.46 \pm 0.05$ for the high luminosity periods, and $kT_{in} = 1.28 \pm 0.02$ keV and $\Gamma = 3.34 \pm 0.05$ for the low luminosity one. While we can see a slight evolution of the disc temperature and the powerlaw photon index, the inner radius of the disc stays approximatively the same. The flux of the power law however changes drastically. It seems, therefore, that the variability of this class, unlike most of the others, is driven by changes in the powerlaw component usually attributed to Comptonisation of the disc photons by a “corona”. This is compatible with the PCA analysis (Fig. 2) where no apparent correlation between the disc parameters and the spikes are visible, while the variations of the power-law photon index may be tightly linked to changes of luminosity. Analysis of this observation with more physical elaborated models is in progress (Hannikainen et
Simultaneous INTEGRAL/RXTE observations of GRS 1915+105

Steady state observation: Energy dependence of the low frequency QPOs

From INTEGRAL revolution 53 on, GRS 1915+105 was found in its steady “hard” state (class $\chi$ from Belloni et al. 2000). The huge multi-wavelength campaigns performed during revolutions 57 and 62 (Fuchs et al. 2003, 2005, in prep.) revealed the simultaneous presence of a strong compact jet, a hard X-ray tail, and strong Quasi Periodic Oscillation (QPO, at least during revolution 57 when we had simultaneous RXTE observations), while monitoring with the Ryle Telescope showed that the source was very active in radio at the same time (Fig. 1). The analysis of our whole RXTE data set revealed the presence of strong low frequency QPOs (LFQPO) in each observation with frequencies between 1-2.5 Hz, and amplitudes between 11.5-15 % rms (Rodriguez et al. 2004). Unlike usually observed no correlation was found between the source count rate and the QPO frequency. We studied the energy dependence of the QPO amplitude (QPO spectra) in 22 spectral bins. This allowed us to perform spectral fits and we showed that although the source spectral parameters were similar in all RXTE observations, the QPO spectra differed markedly (Rodriguez et al. 2004): while in the first observation (Fig. 3, right) an obvious cut-off was found (at $\sim 22$ keV), in the following ones the cut-off energy either evolved towards higher energy (up to $\sim 30$ keV), or simply disappeared.

Our spectral studies revealed that the spectra of GRS 1915+105 could be well represented by a thermal comptonisation component, and an extra powerlaw accounting for emission at higher energies (Fig. 3 left). While quite puzzling, those results, and especially the evolution of the cut-off energy in the QPO spectra can be easily understood if we assume that part of the hard X-rays are emitted by the compact jet (through direct synchrotron or synchrotron self-Compton as
expected see e.g. Markoff & Nowak 2004), while another part would come from inverse Comptonisation on the basis of the jet. In this context the QPO would originate in the latter component, while the jet emission would not contain any modulation. The QPO spectra would therefore be due to the relative contribution of both components to the total X-ray spectrum: the stronger the jet, the lower the cut-off energy of the QPO, and vice-versa.

We point out that this interpretation qualitatively matches several observational/theoretical facts. The compact jet model has successfully been used in the fitting of different BH binaries (e.g. Markoff et al. 2001). In GRS 1915+105, there is a need for an additional parameter to account for the hardest part of the spectrum. The compact jet is detected (Fuchs et al. 2003), and is strongest when the QPO cut-off energy is the lowest (Rodriguez et al. 2004). The QPO spectral shape seems to be qualitatively the same as the relative contribution of the Comptonised component to the overall spectrum (Fig. 3).

References

Belloni T., Klein-Wolt M., Mendez M., et al. 2000, A&A, 355, 271
Fender, R.P. & Belloni T. 2004, ARA&A, 42, 317
Fuchs Y., Rodriguez, J., Mirabel I.F., 2003, A&A, 409, L35
Harlaftis E.T & Greiner J., 2004, A&A, 414, 13
Hannikainen D.C., Vilhu O., Rodriguez J., et al. 2003, A&A, 411, L415
Markoff S., et al. 2001, A&A, 372, L25
Markoff & Nowak M. 2004, ApJ, 609, 972
Rodriguez, J., et al., 2004, ApJ, vol 615 (Nov. 1) astro-ph 0407076