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AN UBIQUITOUS HYBRID ORIGIN FOR THE HIGH ENERGY EMISSION OF X-RAY BINARIES AND ACTIVE GALACTIC NUCLEI ?

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Abstract. Most compact objects, in particular X-ray Binaries (XRBs) and Active Galactic Nuclei (AGN), are characterised by X and γ-ray radiation, leading to investigate and compare the physical processes occurring in their high energy emission. We perform various studies on the hard X/γ-ray emission of several Galactic and Extragalactic compact objects. In particular, analyzing data of the spectrometer SPI (20 keV-8 MeV) on board the INTEGRAL satellite, we detect in three observations an emission extending above 200 keV and for the first time even up to 350 keV for a neutron star binary, GS 1826-24. The 25-150 keV spectra are well fitted by a cutoff power law or Comptt model, typical of the persistent thermal emission observed until now. But an excess is clearly observed above 200 keV in the two broadest spectra. They are best fitted by a hybrid "Comptt+PL" model instead of a pure thermal one. Therefore the additional component above 200 keV is probably of non-thermal origin. This non-thermal feature reminds the one found in some black hole candidates and AGNs. Studying several XRBs and AGNs, we evoke that both thermal ("disk+corona" system) and non-thermal (e.g. jet or non-thermal electrons within the corona) emission processes could be involved ubiquitously in the high energy emission of Galactic and extragalactic compact objects.

1 Galactic Compact Objects: Low Mass X-ray Binaries

1.1 The Neutron Star LMXRB GS 1826-24: discovery of a hard tail up to ∼350 keV with a hybrid origin

X-ray binaries present an emission extending up to X/γ rays making them ideal candidates for the INTEGRAL satellite. We analysed two years of Galactic Centre Deep Exposure (GCDE) by INTEGRAL/SPI (20 keV-8 MeV, Vedrenne et al. (2003)) to study the hard X/γ ray emission of X-ray bursters like the Neutron Star XRB GS 1826-24. Its detection limit was set to ∼150 keV with *Beppo*SAX (DiSalvo & Stella, astro-ph/0207219). Analysing 5 GCDE periods from 2003 to 2005, we reveal a hard tail up to ∼350 keV (Fig. 1) for GS 1826-24, representing the hardest emission ever detected for a Neutron Star LMXRB. The hard X-ray emission of LMXRBs is generally explained by a thermal comptonisation of soft photons (kT_{seed}) in a hot region (corona defined by the electrons temperature kT_e and the optical depth τ) probably placed between the neutron star and the accretion disk. The 5 GCDE periods analysed display two spectra do not exceeding 160 keV, as usually detected until now, and reveal the presence of a hard tail in three observations, respectively up to 240, 320 and 360 keV. All spectra can be correctly reproduced by a pure thermal model (Cutoff PL or Comptt). However, for the two broadest spectra a clear excess is observed above ∼200 keV, indicating the presence of an additional component. The "Comptt+PL" hybrid model (Fig. 2) is clearly statistically favored (P_{Ftest} of $1{\cdot}10^{-4}$). The thermal component of the most extended spectrum is characterised by kT_{seed}=0.4 keV, $kT_e=19.17^{+6.1}_{-8.1}$ keV and $\tau=1.84^{+3.1}_{-0.4}$. The index of the non-thermal additional component is $\Gamma_{nt}\sim1.14^{+1.6}_{-0.8}$ (Deluit et al., 2006, to be submitted.). The hard tails present in the two broadest spectra have similar spectral characteristics and are found in the highest flux observations. The flux increase does not seem to be due to an accretion rate modification since that would entail a change in the burst recurrence time of GS 1826-24, that has not been observed (Thompson et al., 2005) but due to the occurrence of the non-thermal component. The thermal component is quite identical for all 5 observations, leading to the conclusion that two distinct regions could be involved in the generation of the thermal and non-thermal component. Whether the origin of the hard tail is non-thermal, the involved photons could be generated either via non-thermal electrons present in the corona or directly from a jet. A multi-wavelength campaign would be of great benefit to definitively identify the region generating the non-thermal hard tail of GS 1826-24 discovered by SPI and the conditions of its triggering.

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1.2 Black Hole Candidates

The SPI spectrum of GS 1826 naturally reminds the one found for BHCs in the hard X/γ ray domain. As an example, XTE J1550-564 (Deluit, in prep.) and Cyg X-1 (Malzac et al., 2005) shows similarities since following their state the emission is composed of both a thermal (cutoff) and non-thermal component (power law) extending even up to the MeV domain for Cyg X-1. Analysing 3 revolutions of SPI data of the 2003 outburst of XTE J1550-564 during a Low/Hard State, we show a spectro-temporal evolution in hard X-rays during the outburst. In the rising phase, the spectrum does not exceed 360 keV and is well reproduced by a pure thermal model (CPL, Comptt or Compps), whereas during the flaring phase, the SPI spectrum reaches 500 keV; and then the emission drops to 320 keV in the ending hard X-ray burst phase (Fig. 3). The most extended spectrum is best reproduced by a hybrid "Compps+PL" model[1], with kT_{seed}=0.52 keV, $kT_e=30^{+11}_{-10}$ keV, $\tau=2.3^{+0.7}_{-0.8}$, whereas the non-thermal component is defined by $\Gamma_{nt}=1.73^{+1.20}_{-1.16}$. The presence of a jet in XTE J1550-564 and Cyg X-1 makes it the ideal candidate to produce the non-thermal emission observed.

2 Extragalactic Compact Objects: Active Galactic Nuclei

BHCs have often been compared to AGNs, and in the last decade, an AGN/BHC binary paradigm has even emerged. AGNs are composed of several classes, mainly radio quiet (e.g. Seyfert) and radio loud (e.g. blazar) objects. The Seyfert galaxies emission is presumed to be due to a pure thermal process with a cutoff detected between 100-300 keV, whereas for blazars, the presence of a dominant non-thermal emission from the jet reaches MeV or GeV domains. Is non-thermal process always absent from the hard X-ray emission of basic Sy 2 ?
In Deluit & Courvoisier (2003) and Deluit (2004), we show that Sy 1 and Sy 2 with Polarized Broad Lines (PBLs hereafter) present common properties with in particular a clear detection of a cutoff. On the contrary, Sy 2 without PBLs detected do not seem to exhibit a cutoff, leading us the hypothesis that another emission process, probably non-thermal, could occur at least in this kind of Sy 2. Furthermore, in Deluit (2004b, PhD thesis), studying the 1996-2004 X-ray emission of the quasar 3C 273, usually dominated by the non-thermal emission from the jet, we detected for the first time in June 2000 and 2001 cutoffs in the 150-300 keV domain in observations having the lowest flux in X-rays and Radio. We then deduced that the jet non-thermal is dominant most of the time, and when its activity and contribution becomes fainter, it lets appear thermal features.

3 Discussion

Studying the high energy emission of different compact objects like neutron star and black hole candidate binaries or AGNs, we emphasise the emergence of a more complex picture of their emission, but also great similarities between all these classes of compact objects. Indeed, it appears that both thermal and non-thermal processes could occur universally in their high energy emission. Remain unknown the conditions of the non-thermal component triggering and its emitting region. The thermal component is well explained by the "accretion disk+hot corona" system. The non-thermal component is natural in the case of a jet presence, like e.g. for Cyg X-1, 3C 273 and Cen A. But for Seyfert galaxies and neutron star binaries for which no jets are observed ? Either non-thermal electrons are present in the corona or we evoke the possibility that collimated outflows or more probably jets extended in small distance scale (i.e. "mini-jet") could be omni-present in radio-quiet AGNs and X-ray binaries presenting an emission above 200 keV.

[1]The addition of a PL is required with a F-test probability of $5{\cdot}10^{-5}$

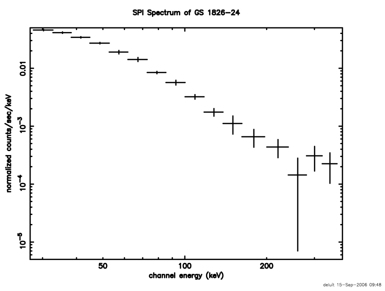

Fig 1: SPI Spectrum of GS 1826-24

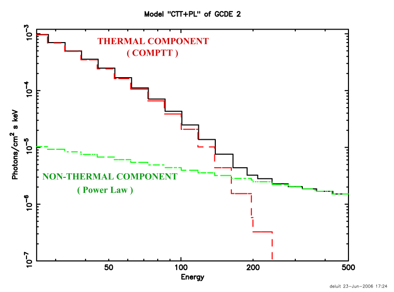

Fig. 2: Model "Comptt+PL" of the GS 1826-24 SPI spectrum

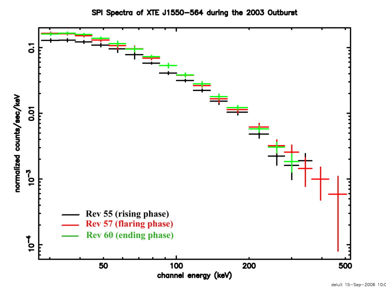

Fig. 3: XTE J1550-564 spectra of the 2003 outburst.

References

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