EMISSION PROCESSES INVOLVED IN THE HARD X/γ RAY EMISSION OF GALACTIC AND EXTRAGALACTIC COMPACT OBJECTS

Sandrine Deluit, Laurent Bouchet, Elisabeth Jourdain

Centre d'Étude Spatiale des Rayonnements (CESR/CNRS/UPS), 9 av. du Colonel Roche, 31 028 Toulouse, France

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 the physical processes occurring in their high energy emission and how their properties scale with different observables like the accretion rate, presence/absence of jets...
We perform various studies on the high energy emission of several Galactic and Extragalactic compact objects. In particular, using the spectrometer SPI on board INTEGRAL, we detect for the first time an emission above 200 keV and even up to 350 keV for a neutron star binary, GS 1826-24, suggesting the presence of another contribution to the classical thermal emission extending until $\sim$150 keV. The processus associated can still have a thermal origin but we favor a non thermal processus, similar to that found in black hole candidates and AGNs. We thus evoke the hypothesis that both thermal (corona) and non thermal (jet or not) emission processes could be involved ubiquitously in the high energy emission of Galactic and extragalactic compact objects.

Key words: X-ray Binaries; Active Galactic Nuclei.

1. GALACTIC COMPACT OBJECTS: X-RAY BINARIES

1.1. The neutron star binary GS 1826-24 with INTEGRAL/SPI: discovery of an emission above 200 keV

X-ray binaries present an emission extending up to X/γ rays making them ideal candidates for the INTEGRAL satellite. We analyzed one year of Galactic Centre Deep Exposure (GCDE) by INTEGRAL, in particular with the Spectrometer SPI (20 keV-8 MeV), giving the unique opportunity to study the hard tail of X-ray bursters like GS 1826-24. GS 1826-24 has been discovered with GINGA while BeppoSAX revealed its neutron star nature showing regular type I bursts.
The BeppoSAX satellite set the detection limit of GS 1826-24 at 150 keV (Di Salvo, 2002), with a cutoff energy found at $\sim$50 keV. The hard X-ray emission of a neutron star system when a cutoff is detected is explained by a thermal comptonisation of soft photons in a hot region (corona) probably placed between the neutron star and the accretion disk.

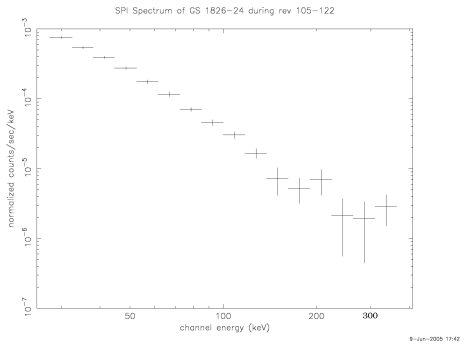

Figure 1. SPI Spectrum of GS 1826-24

With SPI, we reveal for the first time a significative emission extending up to 350 keV (Figure 1). The SPI spectrum still requires the classical thermal cutoff component at 60 keV (Deluit et al. 2006), but the large extension of the emission up to 350 keV, well reproduced by a power law, suggests the presence of an additional contribution. A thermal origin is possible but we favor a non thermal emission since the radiation up to 350 keV would request a hot plasma region, hardly compatible with the Compton cooling expected to reproduce the soft X-ray emission.
The discovery of this new contribution to the classical thermal emission up to 100-150 keV known for neutron star binaries naturally leads to a comparison with other types of compact objects.

1.2. Black Hole Candidates

The spectrum of GS 1826 revealed by SPI, for which several components seem to be present, naturally reminds the one found for BHCs in the hard X/γ ray domain. As an example, Cyg X-1 presenting an emission at much higher energies than for GS 1826-24, shows however similarities with the state for which its emission extends

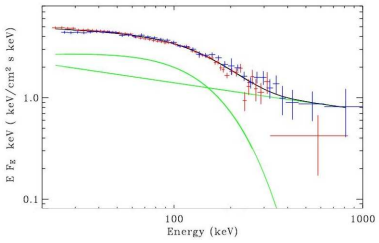

Figure 2. IBIS and SPI spectra of Cyg X-1 in June 2003. From Malzac et al. (2005)

far above the cutoff energy found in the X-ray domain and is composed of both a thermal (cutoff) and non thermal component (power law) extending up to the MeV domain (Figure 2). The presence of a jet in Cyg X-1 makes it the ideal candidate to produce the non thermal emission observed in the γ-ray domain. Moreover, a clear correlation is found between the radio and hard X-ray/γ domain in Cyg X-1, but also for most of BHCs in the low/hard state where the jet is dominant.

2. EXTRAGALACTIC COMPACT OBJECTS: ACTIVE GALACTIC NUCLEI

BHCs have often be compared to AGNs, and in the last decade, an AGN/BHC binary paradigm has even emerged (Figure 3).

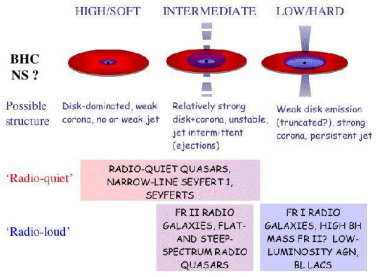

Figure 3. Black Hole Grand Unification (Uttley, astro-ph/0508060)

AGNs are composed of several classes, mainly radio quiet (e.g. Seyfert) and radio loud (e.g. blazar) objects. Their emission extension differs following the class considered, in particular if a jet is present. 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, a dominant non thermal emission from the jet reaches MeV or GeV domains.
In Deluit et al. (2003) and Deluit (2004), we show that Sy 1 and Sy 2 with Polarized Broad Lines (PBLs hereafter) present common properties with a clear detection of a cutoff. On the other hand, 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 in this kind of Sy 2 and in Sy in general.

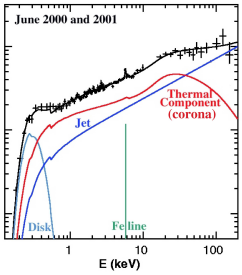

Figure 4. Schematic view of 3C 273 X-ray spectrum in June 2000 and 2001

Conversely, in Deluit et al. (2005), studying the 1996-2004 X-ray emission of the quasar 3C 273, usually largely dominated by the non thermal emission from the jet, we constrain a thermal cutoff in June 2000 and June 2001 observations (Figure 4), corresponding (with June 2004) to the lowest X-ray flux and jet activity states ever observed in the 3C 273 history. That proves that a thermal process is involved in addition to the well known non thermal emission from the jet.

3. DISCUSSION

Studying the high energy emission of different compact objects like neutron star binaries, black hole candidate binaries and AGNs, we emphasize 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 occurred in their high energy emission. 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 3C 273. But for Seyfert galaxies and neutron star binaries for which no jets are observed ? We evoke the possibility that collimated outflows or more probably jets extended in small distance scale (i.e. "mini-jet") could be omnipresent in radio-quiet AGNs and X-ray binaries presenting an emission above 200 keV.
Our various investigations thus suggest that an ubiquitous "thermal+non thermal" origin would be drawn for the high energy emission of galactic and extragalactic compact objects.

REFERENCES

Deluit, S., et al., 2003, A&A, 399, 277
Deluit, S.J., 2004, A&A, 415, 39
Deluit, S., Stuhlinger, M., & Staubert R., 2005, submitted to A&A
Deluit, S., Bouchet L., Jourdain, E., et al., 2006, in preparation
Di Salvo, 2002, astro-ph/0207219
Malzac, J., et al., 2005, submitted to A&A