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SIMBOL–X AND THE GALACTIC CENTRE REGION

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Abstract. Despite huge observational advances in the few last years, the origin and nature of the high energy emission of the Galactic Centre region is still the object of strong debates. We discuss here two problems open in this complex region, and show that the unprecedented characteristics of SIMBOL–X will provide unique clues to solve them.

1 Introduction

The Galactic centre (GC) region is one of the most largely studied region in high energy astrophysics (Melia & Falcke 2001). Besides its probable link with the large scale 511 keV annihilation line, its interest lies in particular in the now unambiguously identified supermassive Black Hole at its center, the closest that we can study, as well as its enigmatic X–ray diffuse emission. This makes the GC one of the prime target of the currently flying high energy observatories, XMM–Newton and Chandra for X–rays, and INTEGRAL for gamma–rays. They are all devoting large programs to the observation of this region.

Despite these efforts, the large differences in instrumental capabilities between the current X–ray and gamma–ray telescopes still prevent solving outstanding questions in the GC region, such as those developped in this paper, namely the physics of accretion / ejection onto Sgr A*, and the origin of the X–ray diffuse emission. To solve these questions require a new generation of instruments, which have in the hard X–ray range the performances of the current "X–ray" telescopes. This is precisely what will be achieved by SIMBOL–X. A full description of this mission can be found in Ferrando *et al.* (2003) (see also Ferrando, this volume). In the following sections, we specifically show how SIMBOL–X observations will give unprecedented insights in the above mentionned problems.

2 The accretion onto Sgr A*

The measurements, in infrared, of stars proper motions near the Galactic Center have definitely proven that our Galaxy hosts a supermassive Black Hole of ~ 3.6 million $M_{\odot}$ at its dynamical center (Einsenhauer *et al.* 2003 and ref. therein),

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coincident with the strong radio source Sgr A*. Despite its environment from which a strong accretion can be expected, this source is extremely quiet at all wavelengths other than radio. In fact, the Sgr A* X–ray emission could be measured only recently, at a level of about 10^{-11} orders of magnitude less than its Eddington luminosity in quiescence (Baganoff *et al.* 2003). The source was also shown to have a frequent flaring activity, with the best spectral results, obtained by XMM–Newton, showing puzzling different spectral shapes (Goldwurm *et al.* 2003, Porquet *et al.* 2003). At higher energy, Bélanger *et al.* (this volume) have reported the first detection, with INTEGRAL, of a significant emission above 20 keV, consistent with a point source at the position of Sgr A*. However, the 12′ angular resolution of INTEGRAL does not allow them to definitely conclude about the source of this emission in this crowded region of the sky.

This extremely low luminosity of Sgr A*, contrasting with the powerful output of AGN's which contain Black Holes of similar mass in their centre, remains a challenge to theory. A number of models are competing to explain what is generally believed to be a radiatively inefficient accretion. The two models most favored today, able to account for the observed variability time scale, are those which attribute the emission to a jet (Falcke & Markoff, 2000), and those for which the emission is rather coming from the inner regions of the accretion disk, in the hot Keplerian flow present within the circularization radius of a spherical flow (Liu & Melia 2002). Both type of models have predictions for the high energy emission which can be either Bremstrahlung or synchrotron dominated depending on physical characteristics of the source, such as the disk viscosity for the hot Keplerian flow model, or the electronic temperature, the jet power, or the importance of shocks in the different scenarii of the jet model (Markoff *et al.* 2001)).

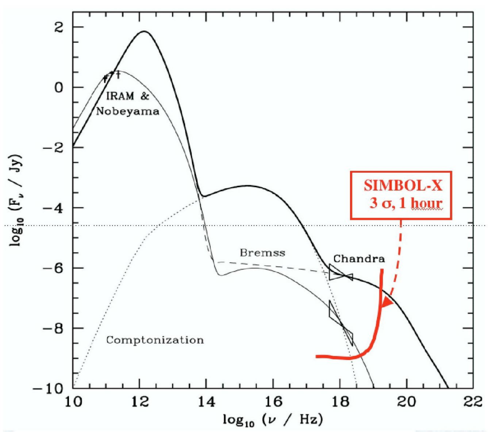

Fig. 1. SIMBOL–X sensitivity, for a 3 σ measurement in a 1 hour observation, compared to the Bremstrhalung dominated hot Keplerian flow model of Liu & Melia (2002).

The sensitivity of SIMBOL–X is compared to the predictions of one of these models in Fig. 1. Coupled with its angular resolution comparable to that of XMM–Newton, sufficient to avoid the confusion problems encountered by INTEGRAL, SIMBOL–X will be able to monitor the high energy activity of Sgr A* up to several tens of keV from quietness to strong flares, and to measure the spectra of these flares. In particular, the unique sensitivity above 10 keV will allow to unambigously determine which of Bremstrahlung or synchrotron is the dominant process, something impossible with the current generation of instruments. It will also be possible to study temporal microstructures at high energy in the flares. These spectral and temporal informations are unique clues for establishing if the flaring activity of Sgr A* is mainly due to accreting matter or ejection process, as well as for constraining the physical parameters at play.

3 The origin of the diffuse emission

Since its discovery more than 30 years ago, the origin of the high energy diffuse emission from the Galactic ridge and in particular the Galactic Centre remains enigmatic. The first CCD spectro-imaging data, by ASCA, were interpreted as signing the presence of a plasma at ~ 10 keV, too hot to be gravitationnally bound to the Galaxy (Koyama *et al.* 1996). Since then, the much better angular resolution data of Chandra have shown that ~ 10 % of the ASCA flux is due to identified point sources (Muno *et al.* 2003). This still leaves ~ 90 % of it unexplained except if one extrapolates the luminosity function of the identified sources two orders of magnitude below the current detection limit. This would however not account for the different Fe K lines profiles in the diffuse emission compared to point sources spectra (Wang *et al.* 2002), as well as for the spatial variations of the spectrum (Warwick 2002).

If the presence of a diffuse component is thus not questionned, its nature is still debated. In order to avoid the energetics difficulties with having the ~ 10 keV plasma mentionned above, models involving the mixing of thermal and non thermal components have been proposed. One model suggests a non thermal emission arising from the interaction of Low Energetic Cosmic Ray Electrons (of ~ 100 keV) with the Interstellar Medium, added on top of a ~ 3 keV plasma thermal emission (Valinia *et al.* 2000). Another model rather suggests that the non thermal part of the X–ray spectrum is due to a population of quasi-thermal electrons located in regions of particle acceleration, while the thermal part would necessitate a ~ 0.5 keV plasma temperature only (Dogiel *et al.* 2002).

In order to really elucidate the origin of the Galactic Centre diffuse component, one needs to map this region up to several tens of keV. This is the only way to unambiguously separate the thermal and non thermal part of the spectra, which are strongly mixed below 10 keV. The non-thermal map will then be compared to maps at lower energies, as well as to the maps of neutral and ionized Iron, in order to identify the particle population responsible for this emission.

The spectro-imaging capabilities of SIMBOL–X on this subject are demonstrated in Figures 2 and 3. Figure 2 shows the XMM–Newton 8–10 keV continuum map in the GC, on which has been indicated the 6 arcmin SIMBOL–X Field of View, as well as a 1 arcmin^2 region. Figure 3 shows a simulated spectrum measurement of this region, using a model mixing the thermal emission of a nonequilibrium plasma with a non thermal power law emission, model fitting the XMM–Newton observations. In typical 100 ks observations, SIMBOL–X will be able to measure such spectra up to 50 keV, and will thus unambiguously measure the importance and characteristics of the non-thermal emission. With a total observation time of ~ 2 Ms, corresponding to ~ 10 pointings, SIMBOL–X will provide a unique non-thermal map of the Galactic Centre region extending up to the radio arc.

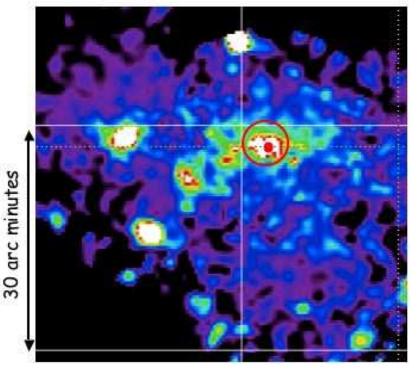

Fig. 2. XMM–Newton map of the GC in the 8–10 keV band. The open circle shows the SIMBOL–X FOV, while the thick dot inside it represents a 1 arcmin^2 region.

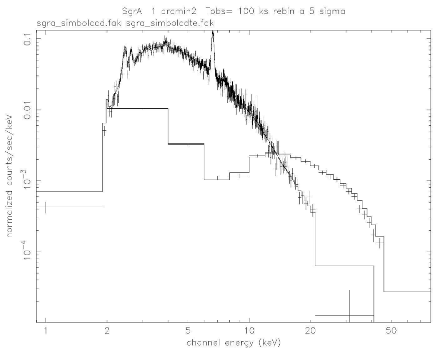

Fig. 3. Simulated SIMBOL–X spectrum of the diffuse emission in the 1 arcmin^2 region of Fig. 2; the data from the SDD and CZT detectors are shown separately.

4 Other scientific objectives

We have demonstrated above what will be the impact of observations made with SIMBOL–X on fundamental problems in the nucleus of our Galaxy. A last example in this region, that we have no space to develop here, is the possibility with SIMBOL–X to test the proposed identification of the EGRET source 2EG J1746-2852 with Sgr A East (Melia *et al.* 1998), by measuring its non thermal spectrum. Finally, it is worth mentionning that, although one of the most important, the Galactic Center is only one of the scientific objectives of SIMBOL–X. Similar advances are expected in the other objectives of this mission (see Ferrando *et al.* 2003 for a summary).

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