PROCEEDINGS OF SCIENCE

Prospects in polarimetry with the Simbol-X mission

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The Simbol-X project is a new generation high energy telescope operating in the 0.5 to 80 keV energy range which will take advantage of the emerging spacecraft formation flying technology. Simbol-X will study the most high-energy phenomena in the universe with an excellent image definition and sensitivity along with a very good spectral resolution. The focal assembly of the Simbol-X telescope is formed by two superimposed spectral imaging systems, so the Compton mode can be used for polarimetric studies. After a brief description of the mission, we present our first results in this mode based on numerical simulations. We conclude that Compton polarimetric studies in the hard X-rays range with Simbol-X prove to be a reasonable complementary scientific topic of the mission.

Polarimetry days in Rome: Crab status, theory and prospects
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[1] Speaker

1.Introduction

Polarimetry has been used since years as a very powerful tool to look deep inside many celestial sources. Along with imaging and spectroscopy, polarimetry has proven to bring much relevant informations like acceleration and nature of particles during solar flares or more far away in QSO. In the high energy range, polarization measurements are particularly important for studies of pulsars, accreting black holes with jets, active galaxies or gamma-rays bursts. Nevertheless, this window has been poorly studied despite many attempts. Until recently, the only source outside of the Solar system with clear polarization detection in X–rays has been the Crab nebula (Weisskopf et al. 1976, 1978) in the low energy range between 2.6 and 5.2 keV. Nevertheless a major breakthrough came in 2008 with two independent measurements of the Crab nebula polarization above 200 keV, thanks to the instruments SPI and IBIS on board the INTEGRAL satellite (Dean et al. 2008, Forot et al. 2008, Laurent et al., 2009). In these cases, the Compton diffusion of hard X-rays/gamma-rays has been used to characterize the polarization of the source. Such an approach appears to be an efficient mean to study the polarization of celestial sources in the hard X-rays range.

2. The Simbol-X mission

Simbol-X is a hard X-ray mission conducted in collaboration between the French and Italian space agencies with participation of German laboratories, and operating in the 0.5-80 keV energy range. Foreseen to be launched in 2015, it will take advantage of the emerging spacecraft formation flight technology (Ferrando et al. 2008). Pushing the grazing incidence imaging up to nearly 100 keV, Simbol-X will provide a strong improvement in terms of both angular resolution and sensitivity compared to all instruments that have operated today above 10 keV.

2.1 Formation flight concept

The basic concept of the mission consists of two spacecrafts, one carrying the mirror, the second the detector system (Fig. 1). The Simbol-X optics is a unique multilayer Wolter I nested shells mirror that will focus the X-rays onto the focal plane detector system. To achieve a good efficiency up to at least 80 keV, a long focal length is required, 20 m in the case of the Simbol-X mission.

2.2 Detector payload

The focal plane of the Simbol-X telescope is composed of two imaging detectors on top of each other (Fig. 2), the Low Energy Detector (LED) and the High Energy Detector (HED). Both detectors are covering 8×8 cm^2 with 625 μm pixels. They have a flexible read-out and are operated at moderately low temperature (–40°C). The LED and HED measure the position of the incoming photon, its energy and the onboard arrival time. Active and passive systems protect the detectors against the cosmic rays (more details are given in Laurent et al., 2008.)

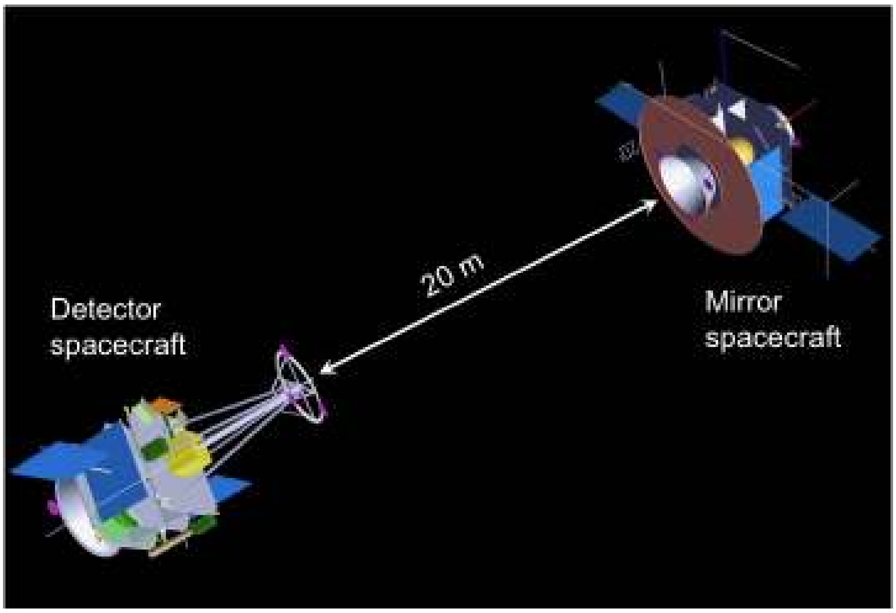

Figure 1: Sketch of the Simbol-X mission. The mirror and the detector spacecrafts are separated by 20 meters. The two spacecrafts will be launched together by a Soyouz-Fregat vehicle from Kourou into a High Elliptical Orbit.

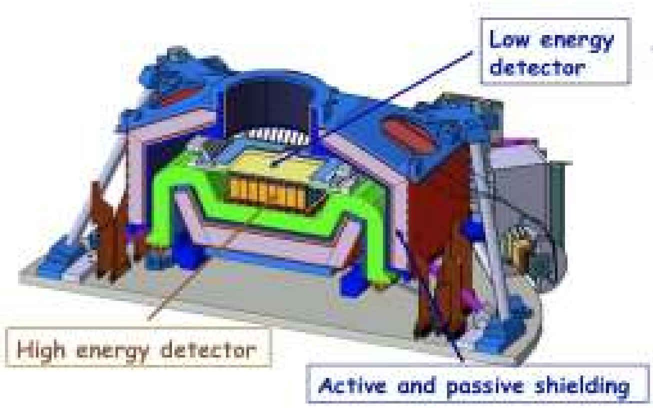

Figure 2: At the focal plane of Simbol-X, the two detectors: the Low Energy Detector (LED) on top the High Energy Detector (HED). They are shielded by a system of active and passive systems. The separation between the two detector layers is 1 cm.

3. Polarimetry with Simbol-X

The focal plane of the telescope being formed by two superimposed spectral imaging systems, we investigated its feasibility as a Compton telescope. This mode, as shown by the recent INTEGRAL results on the Crab nebula, has proven to be a mean to conduct polarimetric studies on bright objects. Following the same strategy as for the INTEGRAL/IBIS studies, we have evaluated the sensitivity of Simbol-X in Compton/polarimetric mode using GEANT3 Monte-Carlo simulations and the GLEPS package[1].

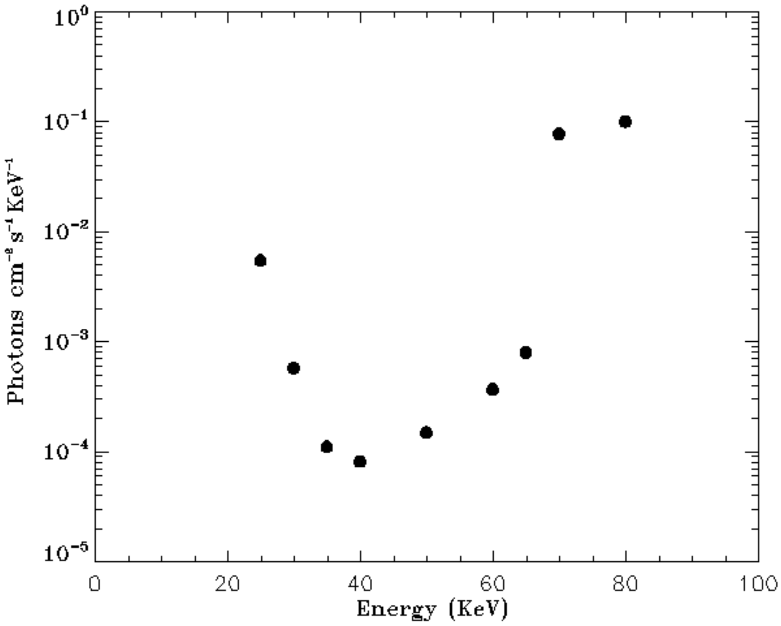

Figure 3: Sensitivity of Simbol-X, at a 5 sigma level, for a 100 % polarized source as a function of energy for a 100 ksec exposure time. The curve clearly shows a maximum efficiency between 25 and 60 keV, combination of both the Compton efficiency process and the Simbol-X sensitivity response.

From this first study, we estimate that a minimum detectable polarisation fraction of 35 % can be measured for a 100 mCrab source in 10 ksec (assuming a Crab like spectrum) between 20 and 80 keV. Many aspects of this study need to be investigate more in details but this preliminary result is encouraging.

As shown in Fig. 4, the spatial resolution and sensibility of the Simbol-X mission will also allow mapping in detail at a level of a few arcseconds the inner region of the Crab nebula. For polarimetric emission, this might bring a clue to a better understanding of its origin.

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[1] GLEPS is a package for handling polarization with Geant 3 developed by Dr. Mark McConnell at the University of New Hampshire, USA.

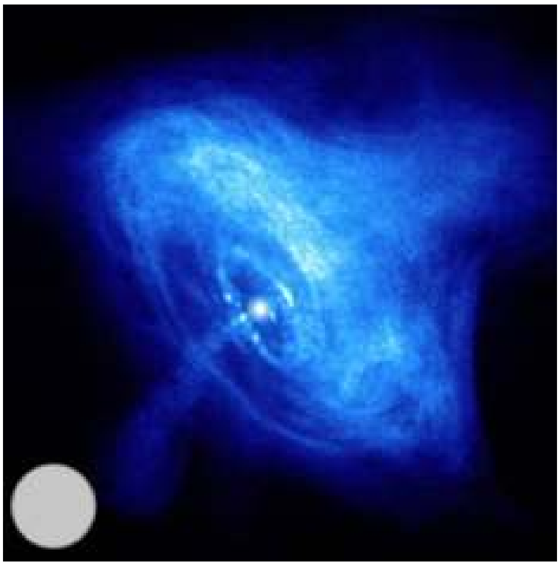

Figure 4: Chandra image of the inner part of the Crab nebula. The grey spot shows the Simbol-X point spread function, 20 arseconds.

4. Conclusions

Compton polarimetric studies with Simbol-X in the hard X-rays range prove to be a reasonable complementary scientific topic of the mission. Not designed to study this new and exciting window of the universe, the Simbol-X mission, thanks to its sensibility and angular resolution, may help to better understand the physics of compact objects inside our galaxy.

The authors want to thank the organisers for this fruitful and very pleasant workshop in Rome.

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