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Probing acceleration mechanism of non-thermal electrons in young stellar objects

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Abstract.
We discuss the origin of the Fe 6.4 keV fluorescence line observed in the X-ray spectrum of Elias 29 in ρ Oph. The observed properties are not compatible with photoionizaion emission and an explanation in terms of collisional ionization by a beam of non-thermal electrons is presented. Simbol-X will be able to test this hypothesis and to establish the presence of particle acceleration to high energies in the magnetosphere of a young stellar system.

Key words. Stars: pre main sequence – Stars: flare – X-rays: stars

1. Introduction

The nine-days long XMM/Newton observation of ρ Oph (DROXO, Pillitteri et al. in preparation) has detected variability in the equivalent width of the Fe 6.4 keV fluorescent emission line from the pre-main sequence star Elias 29 (Giardino et al. 2007). The observed thermal spectrum does not have enough hard ionizing photons to produce the observed large fluorescent equivalent width (150-250 eV, Fig. 1). Furthermore the observed variability in the equivalent width of the fluorescence line is not related with variations of the X-ray thermal spectrum therefore a sustained mechanism ionizing the neutral Fe atoms must operate on time scale of days.

Collisional ionization of K-shell electrons by a beam of non- thermal electrons is a possible explanation (see Emslie et al. 1986 for a similar phenomenon in solar flares or Osten et al. 2007, for a stellar case). This hypothesis is consistent with a magnetospheric accretion scenario, where disk material is magnetically channeled from the accretion disk. The observation of very intense long-duration flares (Favata et al. 2005) in young stars provides evidence for flaring associated to these accretion streams. In this scenario the magnetic fields channeling the accretion streams are constantly stressed by the differential rotation velocity between the star and the disk. This provides a natural continuous ”engine” for the reconnection events.

2. The diagnostics

The non-thermal electron population required to explain the observed Fe 6.4 keV line will be detectable through their brehmstrahlung radiation. We have modeled the emitted spectrum using the Emslie et al. (1986) model, which provides a relationship between the ob-

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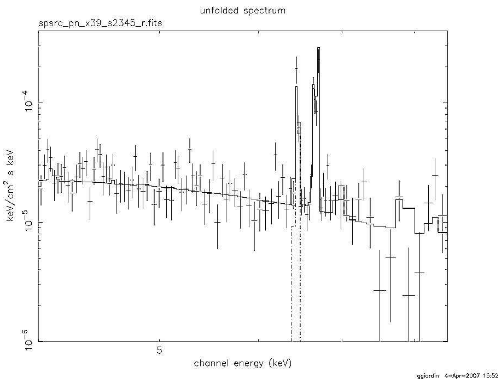

Fig. 1. The XMM spectrum of El 29 in the band from 4 to 8 keV from the Droxo project together with the best fit model (Giardino et al. 2007). Note the strong Fe 6.4 keV fluorescent line.

served 6.4 keV flux and the power-law emission of the non-thermal electrons. We have investigated whether this non-thermal emission (invisible in the XMM observation) can be detected with a Simbol-X observation. We have produced simulated spectra (including background) for a 500 ks observation of Elias 29. The model is composed of the thermal spectrum and fluorescence line observed by XMM plus the power-law spectrum predicted by the Emslie et al. (1986) model.

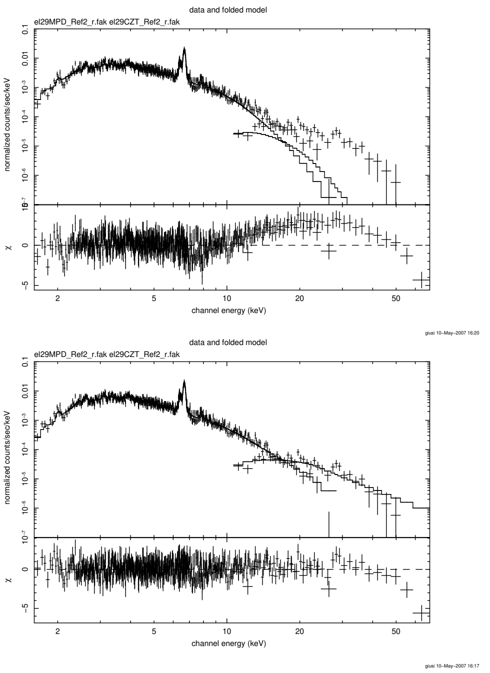

Fig. 2. The simulated X-ray spectrum of El 29, including the non-thermal component due to the non-thermal electron population, as seen by Simbol-X in a 500 ks observation. The upper panel shows the best fit without the power law, the lower panel the best fit with the power law.

3. Conclusions

Simbol-X will be able to observe with ease the power-law spectrum associated with the non-thermal electrons likely to be the cause of the observed strong fluorescent emission in Elias 29. Simbol-X therefore offers an unique opportunity to establish the presence of particle acceleration to high energies in the complex magnetospheres of young stellar systems. The broad band of Simbol-X will allow us to directly link the 6.4 keV line with the injection of non-thermal electrons Non-thermal particle beams offer a clear explanation to the observed intensity and of the variability of the 6.4 keV line.

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