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An universal flaring mechanism from the Sun to the stars?

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Abstract. We present an analysis of solar flares and its extension to active stars with the goal to investigate the observability of non-thermal components of stellar flares with future instrumentation, in particular with Simbol-X. We derive a scaling law for the relationship between soft (thermal) and hard (non-thermal) peak X-ray fluxes which we extrapolate from the solar case to energetic stellar flares.

Key words. Sun: X-rays – Stars: flare – X-rays: stars

1. Introduction

In the Sun flares are mostly attributed to heating of chromospheric plasma by non-thermal electrons (the "thick target" model). This implies a causal connection between the thermal (soft) and non-thermal (hard) X-ray emission during a flare (e.g. the "Neupert effect"). However the extrapolation to stellar flares is not straightforward since stellar X-ray flares have been observed to be up to 6 orders of magnitude more intense than in the Sun and therefore it is not obvious that they can be explained with mechanisms similar to solar flares.

We perform study of solar and stellar flares using as diagnostics the peak flux in a number of bands: the 1.55-12.4 keV band and two hard bands, 20-40 keV and 60-80 keV. In the Sun data for a number of flares are available, in the hard bands, from RHESSI, and in the soft band from GOES. For 4 stellar flares data in the same bands are available from SAX MECS and PDS observations (Isola et al. 2007). The two hard bands will be observable by Simbol-X.

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2. The Sun

For our sample of solar flares a clear correlation between peak fluxes is observed as shown in Fig. 1. The best-fit laws are:

$$F_G \sim 7.8333 \times 10^{-6} F_{20-40}^{0.73} \tag{1}$$

$$F_G \sim 1.015 \times 10^{-4} F_{60-80}^{0.58} \tag{2}$$

where F_G is the flux observed in the GOES band and F_{20-40} and F_{60-80} are fluxes observed in the hard bands. The observed correlations provide a good fit to the data over more than 3 orders of magnitude in flux.

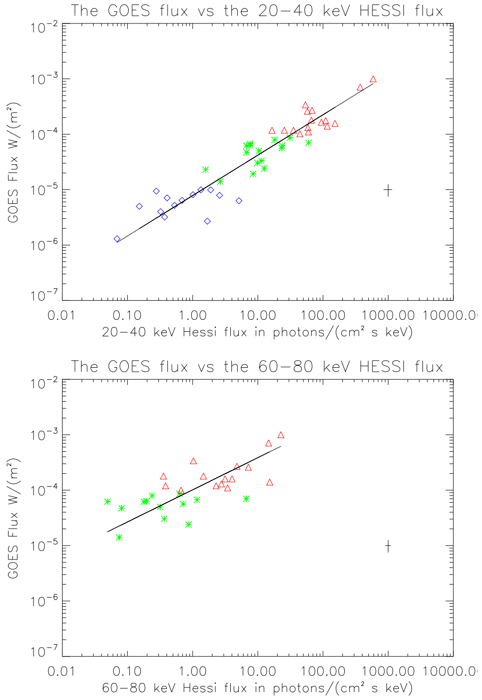

Fig. 1. The correlation observed in a sample of solar flares between the peak flux in the GOES band and the 20-40 keV flux (upper panel) and the 60-80 keV flux (lower panel). The continuous lines are best fit power-laws to the data.

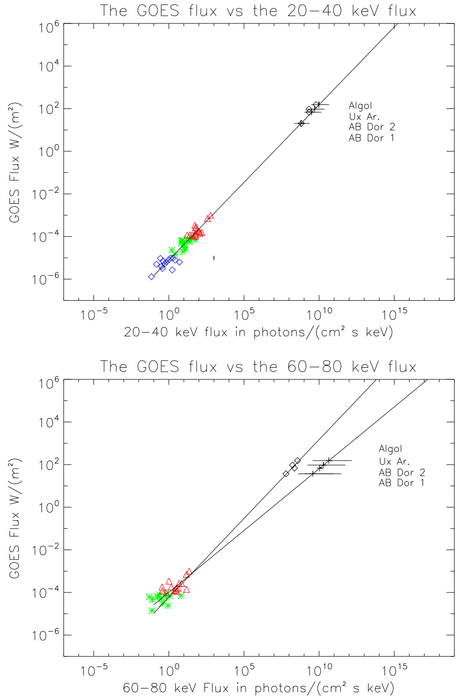

Fig. 2. Soft X-ray emission vs. hard emission for the solar and the stellar flares, plotted with the relative scaling laws. Diamonds correspond to the four stars detected with the PDS (Isola et al. 2007). In the lower panel two fits are presented, an extrapolation of the solar scaling law and a joint solar-stellar fit.

3. Extension to the stars and the role of Simbol-X

Four intense stellar flares (on Algol, UX Ari, and 2 events on AB Dor) have been detected with the SAX PDS. They provide a comparison sample to study the extension of the solar relations by 6 orders of magnitude.

The extrapolation of the solar relation in the 20-40 keV band perfectly fits the four stellar events (upper panel of Fig. 2). The nominal extension of the solar law in the 60-80 keV band over-predicts the hard flux in the stellar flares. However, a joint fit of the solar and stellar events still provides a good empirical law fitting all the events studied.

Simbol-X will be the first X-ray observatory with the required capability to observe a significant number of stellar events across a broad energy band. Simbol-X will allow to sample relatively weak stellar flares, exploring the uncovered range in Fig. 2. This will allow to test our hypothesis, based on only 4 obvserved events, of a "universal" spectral shape in flares, and thus of a common mechanism.

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References

Favata F., Flaccomio E., Reale F. et al. 2005 ApJS, 160, 469

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