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Active stars: quiescent coronae or continuous flaring?

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Abstract. We discuss the capability of Simbol-X in establishing the origin of the quiescent X-ray emission of active stars whose properties may be hardly reconciled with a scaled version of the solar emission. A possible explanation requires a large number of overlapping flares that mimic a pseudo quiescent emission. This hypothesis will be tested by Simbol-X that may observe the non-thermal hard X-ray emission linked to flaring activity.

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

1. Introduction

The nature of the soft X-ray emission of active stars is yet unexplained. Active stars, typically young fast rotating stars or stars in binary systems, may have a "quiescent" X-ray emission up to three orders of magnitude larger than that of the Sun (eg. Fig. 1). This emission is believed to be of coronal origin but the amount of hot plasma cannot be explained just in terms of an increased number of quiet solar structures (e.g. Drake et al. 2000). Some physical differences from the solar corona should be invoked to explain the properties of very active stars.

The process responsible for high activity has to produce at the same time the high activity level and the observed hot temperature. An often invoked possible explanation is that the observed emission is indeed a pseudo-quiescent emission due to a large number of unresolved overlapping flares. The average observed properties do not contradict this hypothesis but with present day observations we cannot prove or disprove it. Possible diagnostics of such hypothesis is the detection of a non-thermal component even during the quiescent phase. Indeed if the emission is really quiescent we do not expect to detect non-thermal emission, while if the emission is due to the overlap of a large number of flares of different amplitude we expect to observe the sum of the non-thermal emissions from those flares. The observed quiescent emission of the active stars is consistent with a continuous flaring emission following a power law relation (see e.g. Caramazza et al. 2007 in press)

$$\frac{dN}{dE} = k \cdot E^{\alpha} \qquad (1)$$

that gives the number of flares of a given total energy E. The parameters of this equation (the α index and the energy cutoff needed to avoid divergency) may be derived from the observed average soft luminosity and from the properties of the light curves giving us the

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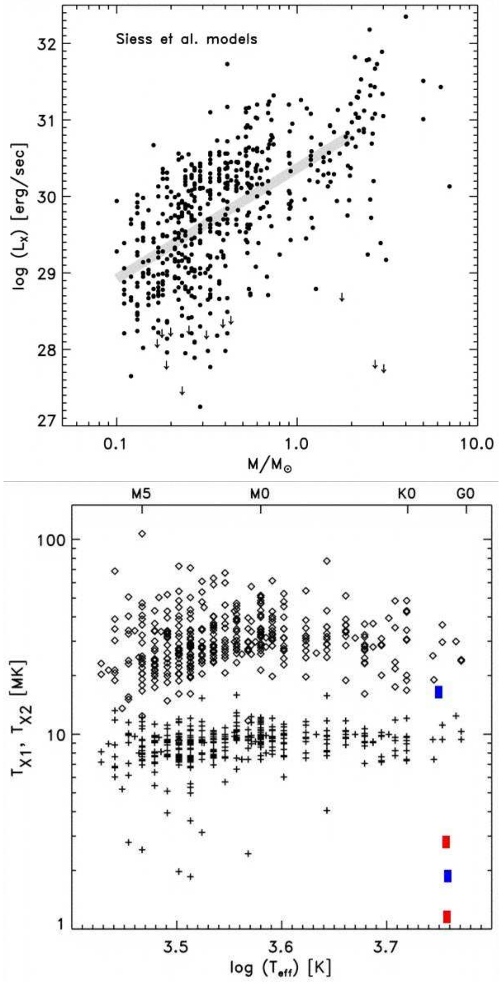

Fig. 1. X-ray luminosity vs. mass in pre-main sequence stars of the Orion Nebula Cluster (upper panel) . For comparison the solar luminosity is in the 26.5 = log(Lx) = 27.5 range. Plasma temperatures in the Orion stars (lower panel). Filled squares represent the solar temperature during the maximum and minimum (Preibisch et al. 2005)

complete description of the flare population that could account for the observed emission.

Isola et al. (2007) obtained a scaling law that links the hard X-ray emission at peak of solar flares (dominated by non-thermal component) with the soft one dominated by thermal emission. Using this scaling law and Eq. 1) we can predict the expected integrated hard X-ray non-thermal emission, assuming that the observed quiescent emission is a superposition of a large number of small flares. The resulting expected luminosity in the (20-40) keV band is related to the integrated soft emission as:

$$L_{(20-40)} = 3.4 \cdot 10^{-14} L_{soft}^{1.37} \qquad (2)$$

that for very active stars corresponds to 10^{-2} - 10^{-3} of the soft emission. Simbol-X will be able to detect such non-thermal luminosity, if present, in a large range of activity levels, effectively testing the origin of quiescent emission in active stars up to distance of 100-200 pc, including young stars, binaries, and dM stars.

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