STELLAR X-RAY POPULATION MODEL AND ABSORBED GALACTIC REGIONS

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ABSTRACT

Two decades ago Einstein observatory observations demonstrated that stellar X-ray luminosity decreases with increasing age. Based on the solar analogy (cooler plasma associated with less X-ray bright regions), one expects a decrease of the mean stellar coronal temperature with time. In order to explore this behavior as seen with XMM-Newton, we used the Xcat-DB and associated cross-identification tools to select a large sample of stellar X-ray sources. The analysis of $\sim$ 130 X-ray spectra with good S/N shows that coronal temperature varies with both age and mass. As the expected XMM-Newton count-rate strongly depends on the assumed emitted spectrum of the source, we introduced an *age and mass dependent* energy conversion factor in our X-ray stellar population model. We compare these model predictions with XMM-observations exhibiting average absorption distribution. In other fields displaying significantly lower source density than on the average, we show that logN(>S)-log(S) curves are compatible with the presence of strong and nearby absorbing regions.

Key words: Stars: population - Stars: X-rays.

1. STELLAR POPULATION MODEL UPGRADE

1.1. Coronal temperature

In an effort to update the Besançon stellar X-ray population model (Guillout et al., 1996), we present the results of an extensive survey of coronal temperature derived from 127 XMM-Newton X-ray sources cross identified with late type stars both in clusters and in the field. For stars in clusters, we observed a clear decrease of coronal temperature (T_{cor}) with age and show that stars cooler than F-type systematically require a plasma consisting of two isothermal components to fit the X-ray spectra while hotter stars only require one temperature. An *age and mass dependent* energy conversion factor as described in

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Table 1. Age and mass dependent energy conversion factor as accounted in the upgraded version of the model.

ECF	A-F type 1 temperature	G-M type 2 temperatures
Pleiades-like	0.6 keV	0.4 - 1.0 keV
Hyades-like	0.5 keV	0.2 - 0.8 keV
Old	0.5 keV	0.2 - 0.8 keV

Table 1 is now taken into account in the upgraded version of the model.

The analysis of coronal temperature distribution of $\sim$ 50 field stellar X-ray sources serendipitously detected by XMM-Newton shows that, in agreement with model predictions, low galactic latitude stars show T_{cor} mostly compatible with *Pleiades-like population* (0.07 Gyrs) while high galactic latitude stars show T_{cor} compatible with *Hyades-like population* (0.7 Gyrs) or older (Fig. 1).

1.2. Absorbing material

With a sensitivity ten times better than ROSAT, deep XMM-Newton observations can probe the youngest late type stars of the galaxy up to 2 kpc. At such distance the patchiness of the interstellar medium can significantly inflect the observed stellar content with respect to average absorbed regions. In the upgraded version of the code, we thus introduced the capability to model the distribution of absorbing material along the line of sight.

2. COMPARISON WITH OBSERVATIONS

2.1. Average absorbed regions

We now compare in Fig. 2 the source density prediction of the model with XMM-Newton observations of average absorbed regions located at low (black), medium

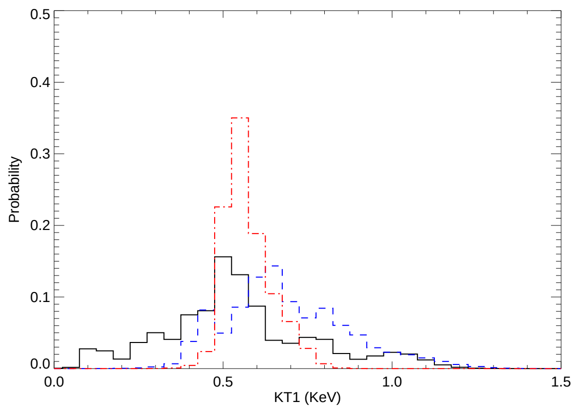

Figure 1. Coronal temperature distribution of F-type stellar X-ray sources detected serendipitously at low (blue dash), medium (red dot-dash) and high (black solid) galactic latitudes.

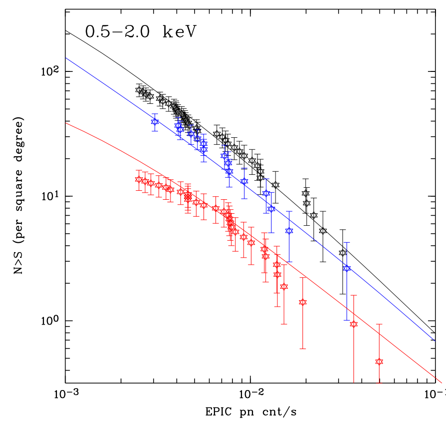

Figure 2. Observed (symbols) and predicted (lines) logN(>S)-log(S) curves at low (black), medium (blue) and high (red) galactic latitudes.

(blue) and high (red) galactic latitudes. The stellar X-ray sources were identified thanks to BVR imagery and low resolution spectroscopic (Canary Islands, ESO,OHP) observations programs carried out by the XMM Survey Science Center (Watson et al., 2001) and AXIS (Barcons et al., 2002) teams. In both regions, the predicted source density is in good agreement with observations. Comparison in several others regions at various galactic latitudes are presented in Hérent et al. (2005).

With a mean absorption of 1.7 mag per kpc, the predicted stellar X-ray source density (black line) is in very good agreement with observations at b = 0° (black symbols). At medium ($|b|$ = 14°) and high (b = 50°) galactic latitudes, the standadrd (0.7 mag/kpc) model predictions (blue and red lines respectively) are compatible with the observed source densities (blue and red symbols respectively). At a sensitivity of 4 10^{-3} EPIC pn cnt/s, according to model predictions, most of the X-ray sources (62%) detected in the galactic plane are at most 150 Myrs old. This fraction is reduced to 26% at mid galactic latitude. Above $|b|$ = 20°, stars older than a gigayears represent the overwhelming population.

2.2. Absorbed regions

In some directions, especially in the galactic plane, the observed stellar X-ray source density can significantly deviate from standard model predictions.As predictions are on the mean in good agreement with observations this behavior is thought to be due to nearby absorption. We then take advantage of the advanced code capability to generate absorption walls (depicted by distance and Av) along the line of sight to accommodate the observed counts. We analyzed two of these XMM observations showing too few X-ray sources than other fields at the same galactic latitude. A grid of models allow us to derive the absorption require to reconcile model with observations.

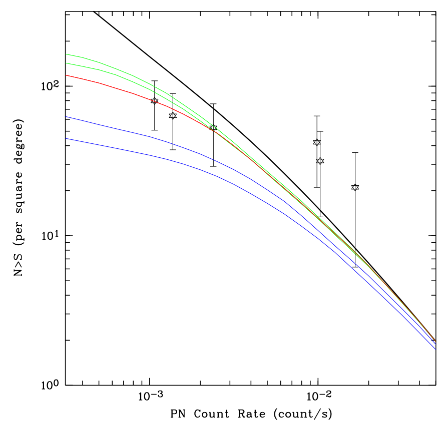

Figure 3. Standard (black) and absorbed (green: Av = 4; blue: Av = 6; both computed for absorption wall at 300 and 400 pc) logN(>S)-log(S) curves in the RXJ0925 XMM-Newton field.

Such an example is illustrated in Fig. 3 (RXJ0925 field). At a sensitivity of $\sim 10^{-3}$ ct/s this XMM observation show 10 times less sources than on the average. An absorption wall of 6 mag at 400 pc (red solid line), consistent with Motch et al. (2002) data, lowers the theoretical logN(>S)-log(S) curve down to the observed density.

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