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Stellar Activity in the Gould Belt

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Abstract.

We have used the database of X-ray sources detected in the ROSAT PSPC pointed observations to search for active late-type stars associated with the Gould Belt. Our cross-correlation with the Tycho-2 catalogue shows an enhancement of X-ray sources positionally coincident with the Gould Belt. Compared to an other study based on the ROSAT all-sky survey we find a substantially larger stellar surface density at the position of the Gould Belt, which is consistent with the higher sensitivity of this data. Furthermore, we find an anticorrelation of longitudinal stellar surface density with intervening ISM.

1. Introduction

The Gould Belt is a disk-like structure that is tilted with respect to the galactic plane where an enhancement of young stars and associated interstellar matter can be found. The existence of the Gould Belt as a physical entity is controversial and its formation is still puzzling. A kinematical study of the stellar content by Comerón (1999) suggests that the Gould Belt is an expanding system with a kinematical age of about 34 Myr, whereas Torra, Fernández & Figueras (2000) derive an age in the range of 30-60 Myr. A cross-correlation of the X-ray sources detected in the ROSAT All-Sky Survey (RASS) with the Tycho catalog has shown that a concentration of active stars seems to be associated with the Gould Belt system (Guillout et al. 1998a). The RASS was carried out during the first half year of operation of the ROSAT satellite. Typical exposure times were of the order of 500 seconds. Details about the satellite and its instrumentation can be found in Trümper (1983) and Trümper et al. (1991).

Here we present first results of an in-depth study of the distribution of X-ray emitting stars along the Gould Belt carried out on the basis of deeper pointed observations with ROSAT. In Section 2 we describe our analysis methods and selection criteria applied to the data. The results obtained so far are presented in Section 3.

2. Analysis

To further investigate stellar activity along the Gould Belt we extended the analysis to deeper exposed X-ray data. Based on all X-ray sources detected in

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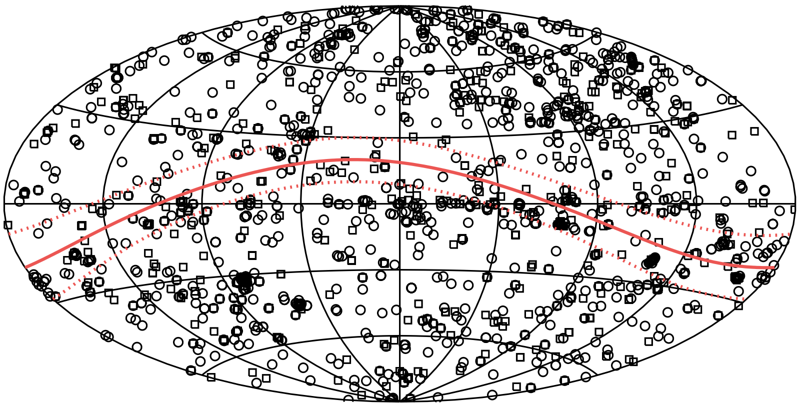

Figure 1. Distribution of ROSAT pointed observations. Circles show PSPC observations with a minimum exposure of 10 ksec whereas boxes represent HRI observations of at least 20 ksec duration. So far the HRI observations are not included in this study.

pointed ROSAT PSPC observations we studied the stellar content associated with the Gould Belt. Altogether, the Second ROSAT Source Catalog of Pointed Observations lists 95331 X-ray sources and the sky coverage is about 14.5%.

From the entire sample of the detected PSPC sources we first selected only those sources which were detected in PSPC observations with a minimum exposure of 10 ksec. This results in a sensitivity that is at least 20 times deeper than for the RASS. Figure 1 shows the distribution of ROSAT pointed observations. In the present state we only considered X-ray sources detected during PSPC observations (circles in Fig. 1). We plan to also include sources detected during the HRI observations in this study. Second, we only considered sources with count rates above a threshold of 10^{-3} counts/sec. This count rate reflects a secure source detection within 10 ksec, excludes fainter sources detected in longer PSPC observations, and results in an almost homogeneous exposure of the covered sky areas. Third, we limited our sample of X-ray sources to those which were detected within the inner ring structure of the PSPC detector (i.e. with an off-axis angle below 25') to minimize source position errors and telescope vignetting effects.

Adopting the best-fit model parameters $i = 27°$ and $l_\Omega = 282°$ for the Gould Belt inclination and the ascending node as derived by Guillout et al. (1998a) we transformed the coordinates of our selection of PSPC sources to the Gould Belt system.

In order to identify the X-ray emitting stars we cross-correlated our sample with the Tycho-2 catalogue (Høg et al. 2000), which provides photometric and astrometric data of the 2.5 million brightest stars in the sky. We chose a maximum acceptable matching distance of 30" and found 1102 sources in this search radius. Next we investigated the spatial distribution of this selection of X-ray emitting stars. First results of this study are presented in the following section.

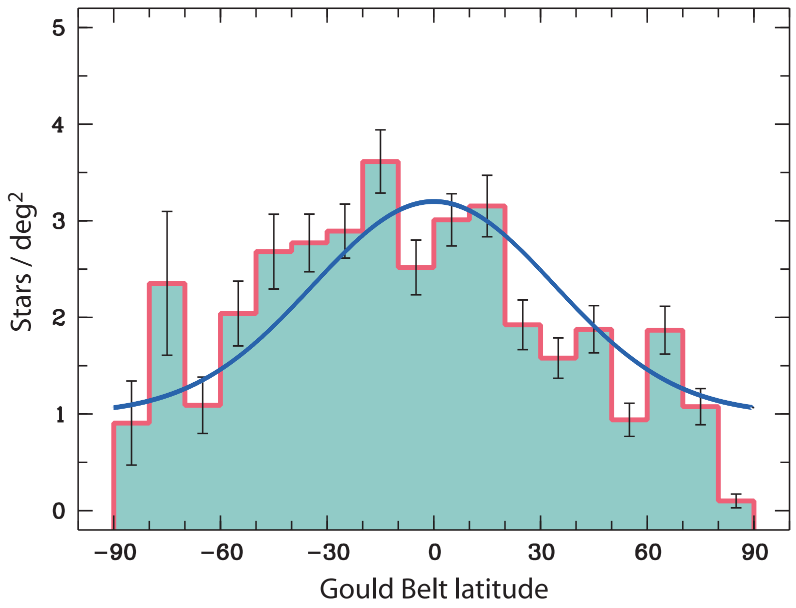

Figure 2. Longitudinally averaged stellar surface density versus Gould Belt latitude. For comparison the best fit Gaussian centered on $l = 0°$ is shown.

3. Results

In order to demonstrate that the Gould Belt can be detected in the ROSAT pointed observations we computed the longitudinally averaged stellar surface density perpendicular to the Gould Belt. Figure 2 shows the results and its statistical uncertainties plotted versus the Gould Belt latitude. An enhancement at the position of the Gould Belt is clearly visible. For comparison the best fit Gaussian centered on $l = 0°$ is included in Figure 2. The stellar surface density at the Gould Belt's equator is about three times higher than the average stellar background determined at higher latitudes. Our results are generally consistent with the findings of Guillout et al. (1998a,b). However, the significantly deeper exposures of the PSPC pointings result in a ten times higher star density for the Gould Belt enhancement.

Now we take a detailed look at the longitudinal distribution of the stellar surface density. Here we only consider stars within Gould Belt latitudes $|b_{\rm GB}| < 30°$. Figure 3 provides the average stellar surface density and its statistical uncertainties as a function of galactic longitude. As can be seen the stellar surface density along the Gould Belt is rather complex. Particularly, a clear peak of star counts in the nearest direction of the Gould Belt at $l \approx 300°$, which one might expect due to a distance effect, is not visible. In order to explore whether the variations in star counts are caused by absorption of intervening interstellar gas we compared the location of the Gould Belt with the distribution of galactic H I gas as obtained by Dickey & Lockman (1990). Note that an interstellar absorption column density of $N_H = 10^{20} \mathrm{cm}^{-2}$ already attenuates the X-ray flux in the ROSAT band (0.1-2.4 keV) by $\sim$30% and subsequently leads to a loss

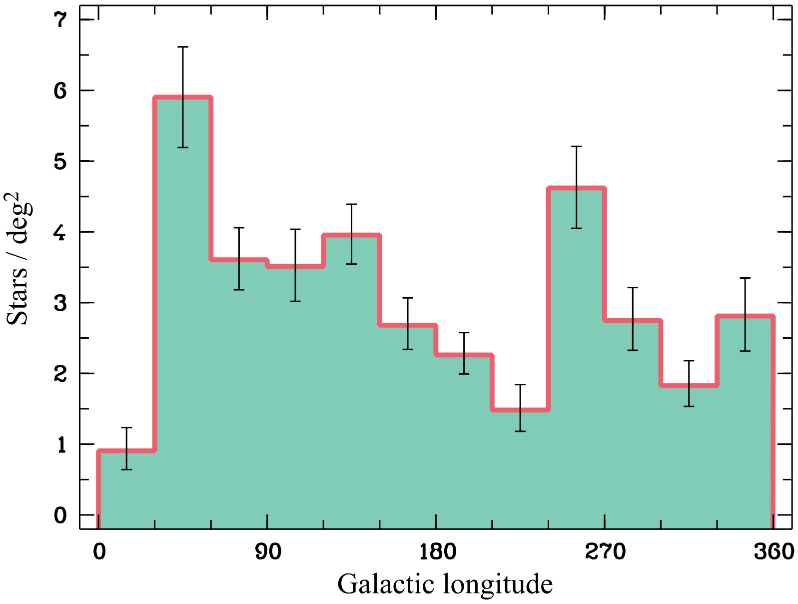

Figure 3. Longitudinal distribution of the stellar surface density averaged within $|b_{\rm GB}| < 30°$ Significant enhancements are observed in directions of lower intervening ISM absorption towards the Gould Belt.

in sensitivity. Regions of high stellar surface density near galactic longitudes $l \approx 30° - 60°$ and $l \approx 240° - 270°$ (see Fig. 3) can be identified as regions of low absorption column densities towards the Gould Belt. Future prospects for this project are to increase the sky coverage by including the stellar X-ray sources detected in ROSAT HRI observations. A detailed modeling is then required to assess the structure of the Gould Belt and the spatial distribution of active late-type stars associated with the Gould Belt.

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