V. X-ray characterization of CARMENES samples

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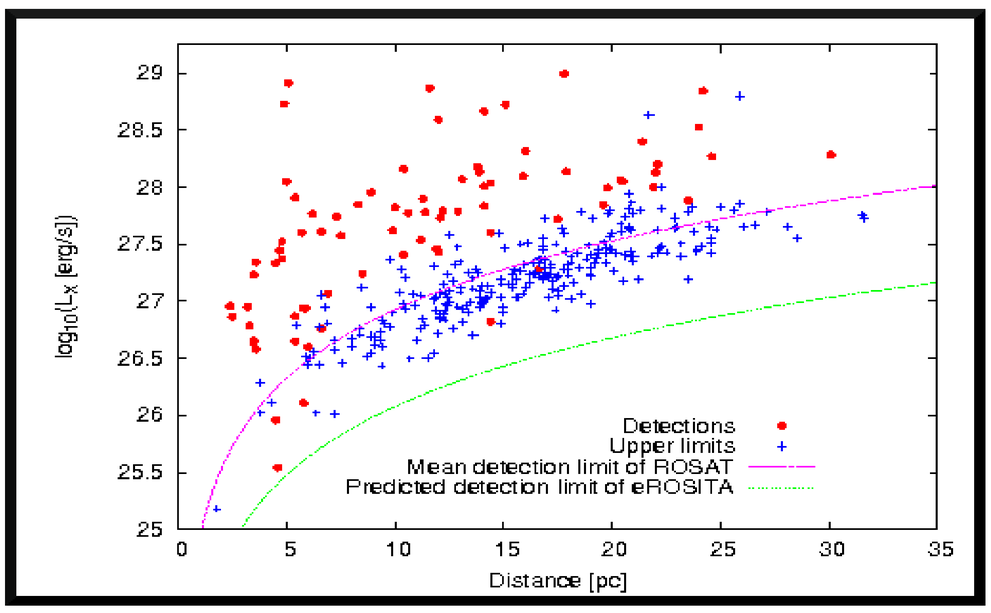
Abstract: With CARMENES it is planned to monitor the radial velocities of about 300 M dwarfs of the CARMENES sample for five years in a search for Earth-like planets in their habitable zones. On such stars magnetic activity is ubiquitously present, and its various manifestations turn out to be an important obstacle to detect low mass, long-period planets. It is therefore essential to characterize the sampled low mass stars in their various activity properties to reliably disentangle RV variations due to spots and other stellar activity from those caused by the presence of planetary companions. Here we present an X-ray characterization of the CARMENES sample of M dwarfs. Our primary database for the X-ray analysis is provided by the *ROSAT* all-sky survey (RASS), which has produced complete and unbiased samples of X-ray sources; we also consider X-ray data from the *XMM-Newton* and *Chandra* Observatories as well as the future *eROSITA* X-ray all-sky survey.

X-ray luminosities



The CARMENES sample is constrained to the observable sky from Calar Alto ($\delta > -30^0$). The *ROSAT* all-sky survey (RASS) discovered more than 120,000 X-ray sources and is the most complete X-ray scan of the sky to date. Cross-matching the ROSAT source catalog with the CARMENES input sample, we identified 24% of the sample stars as X-ray sources. For the non-detections, we calculated 95.6% (i.e., 2σ) upper limits, given the number of background counts expected in the extraction radius and the PSF.
A conversion factor of 6×10^{-12} ergs cm^{-2} counts^{-1} was used to convert count rates into X-ray fluxes and X-ray luminosities.

Figure 1 shows the X-ray luminosity of detected stars (red points) and upper limits (blue crosses) as a function of distance. In our analysis, we achieved a mean limiting sensitivity of 7×10^{-14} ergs s^{-1} cm^{-2}(red dashed line). The green line shows the predicted sensitivity improvement provided by *eROSITA*.

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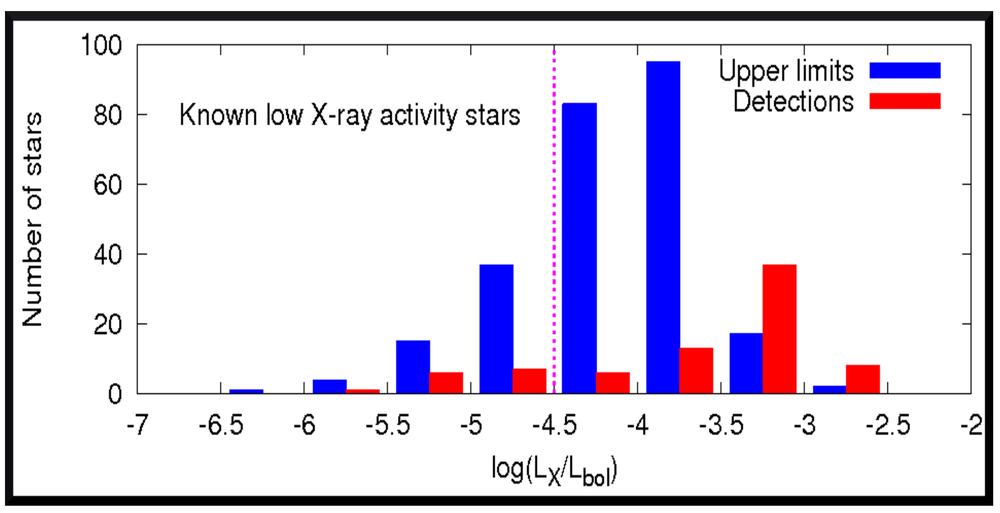
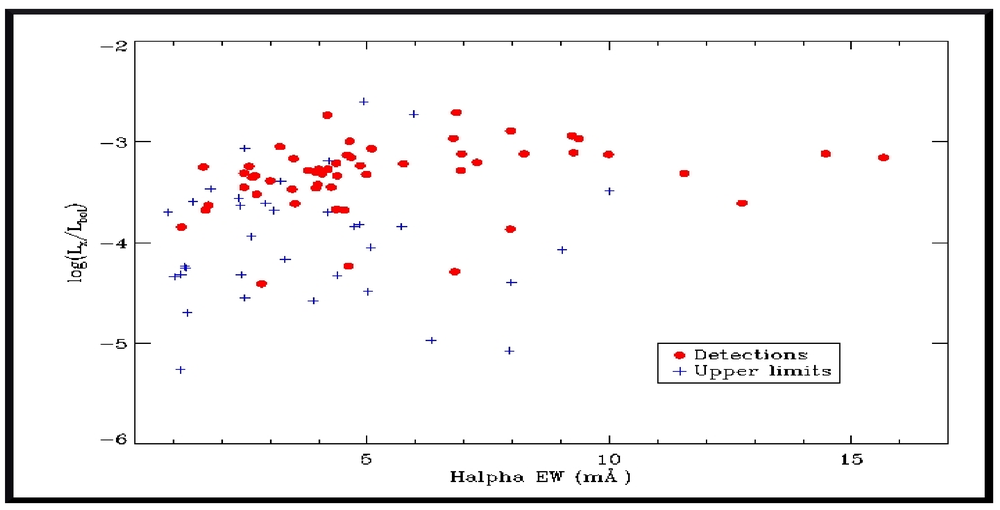
Coronal activity distribution



In Figure 2 we show the distribution of $\log(L_x/L_{bol})$ for the X-ray detections (red) and the upper limits for the non-detections (blue). Not surprisingly, the X-ray detections are the more active stars. The stars with either X-ray detections or upper limits below -4.5 in $\log(L_x/L_{bol})$ belong to our low/moderate X-ray activity sample. For about 60% of the sample stars from the CARMENES input list, the derived upper limits do not rule out substantial activity. While quite a few of these stars may actually turn out to be inactive, the majority of detected stars has X-ray luminosities close to the saturation limit of -3; these can definitely be excluded from the low activity sample.

Chromospheric activity distribution



The most relevant chromospheric activity indicator is Hα emission. In order to investigate the relation between coronal and chromospheric activity, we consider $\log(L_x/L_{bol})$ versus Hα equivalent width (plotted in in Figure 3). As can be seen, large values of Hα equivalent width always lead to X-ray emission near the saturation level between -3 and -4. However, even for smaller values of the Hα equivalent width, high levels of X-ray emission are encountered.

To select the most suitable stars for the search of habitable worlds, it is, therefore, indispensable to provide a panchromatic view of the CARMENES sample stars.