Distribution and Space Density of Soft X-ray Emitting Polars in the Solar Neighbourhood

H.-C. Thomas[1] and K. Beuermann[2,3]

[1] Max–Planck–Institut für Astrophysik, Karl-Schwarzschild-Str. 1, D-85740 Garching, Germany
[2] Universitäts-Sternwarte, Geismarlandstr. 11, D-37083 Göttingen, Germany
[3] Max–Planck–Institut für extraterrestrische Physik, Giessenbachstrasse, D-85740 Garching, Germany

The ROSAT All Sky Survey (RASS) was the first one performed with an imaging telescope in the soft X-ray regime and has led to the discovery of numerous new objects whose emission is dominated by soft X-rays. Among these are white dwarfs and a subclass of the cataclysmic variables (CVs), the Polars or AM Herculis binaries. From a pre-ROSAT census of only 17, the number of known sources of this class has increased to some 55 (Beuermann and Thomas 1993, Beuermann 1997). Distances or lower limits to the distance are available for some 35 of these, based on the detection or non-detection of the TiO-Features in their optical red spectra. The derived distances range from below 100 pc up to $\sim$ 600 pc, implying that many of these objects are located within the "Local Bubble" of low gas density in interstellar space. As the soft X-ray emission can be reasonably well represented by blackbody emission with a typical temperature of $kT_{\rm bb} \simeq 25\,{\rm eV}$, spectral fits to the ROSAT PSPC spectra from either the All-Sky-Survey (RASS) or from subsequent pointed ROSAT observations allow to determine the foreground absorption column density in the direction of the polars.

Considering 9 polars with projected distances in the Galactic plane of $r < 200\,{\rm pc}$, the derived mean atomic hydrogen density is 0.04 ± 0.01 H-atoms $\rm cm^{-3}$. This result excludes 3 systems with substantially larger mean column densities, AM Her ($l, b, d = 79.9°, +25.9°, 90$ pc) with 0.32, RX J1313-33 ($l, b, d = 308.2°, +29.7°$, 170 pc) with 0.65, and RX J2022-39 ($l, b, d = 2.4°, -33.6°, >210$ pc) with 0.63 H-atoms $\rm cm^{-3}$. Five of the 9 polars are located in the 3^{rd} quadrant ($180° < l < 270°$), none in the 1^{st}. In the southern part of the 4^{th} quadrant 4 out of 5 polars indicate densities below 0.04 H-atoms $\rm cm^{-3}$ out to distances of 350 pc. The mean line-of-sight density for the four systems with $r > 400\,{\rm pc}$ is 0.25 H-atoms $\rm cm^{-3}$. The crowding of very soft X-ray sources in certain parts of the sky noted, in particular, for hot white dwarfs (Warwick et al. 1993, Diamond et al. 1995) is similarily found for polars and confirms the conclusions on the structure of local interstellar space deduced from the other types of soft X-ray emitting stars as well as by other methods (e.g. Paresce 1984).

At high Galactic latitudes ($|b| \geq 49°$) the survey of polars is probably complete except for (i) a notable deficiency within the boundaries of the

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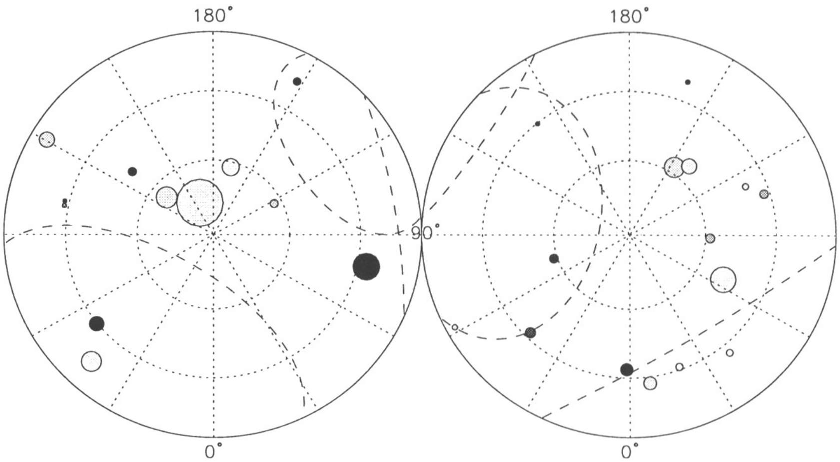

Fig. 1. Mean atomic hydrogen space densities along the lines of sight to the sources for which distances and PSPC spectra are available. The source positions refer to Galactic coordinates with positive latitudes for the left, negative latitudes for the right circle. The grayscale coding implies the following densities: white: 0, black: > 0.3 H-atoms cm^{-3}. The size is inversely proportional to the projected distance in the Galactic plane.

North-Polar Spur and possibly also the Galactic Loops II and III and (ii) a certain fraction of objects which were not detected during the ROSAT survey because they happened to be in an inactive state of low or discontinued accretion. Correcting for these losses in the counts of polars, yields estimates of the space density separately for long-period and short-period polars ($P_{orb} > 3$ h or $P_{orb} < 3$ h, respectively). The two space densities differ by about an order of magnitude which reflects the more rapid evolution in time of the long-period over the short-period polars due to magnetic braking (momentum loss by a magnetized wind) and gravitational radiation, respectively. Assuming a Gaussian density distribution, the derived space density in the Galactic plane is $n_o \simeq 6.1\,10^{-7}pc^{-3}$. Corrected for losses and splitted according to orbital period the space density can be as high as $1.2\,10^{-6}pc^{-3}$ for short-period polars and $1.7\,10^{-7}pc^{-3}$ for long-period polars. The standard deviation of a Gaussian density distribution perpendicular to the Galactic plane was determined to be $\sigma \simeq 155$ pc, compatible with that derived for non-magnetic Cataclysmic Variables (Patterson 1984).

Our study of polars confirms the low mean particle density of the local ISM interspersed with some denser clouds. In some directions these low densities extend to large distances,

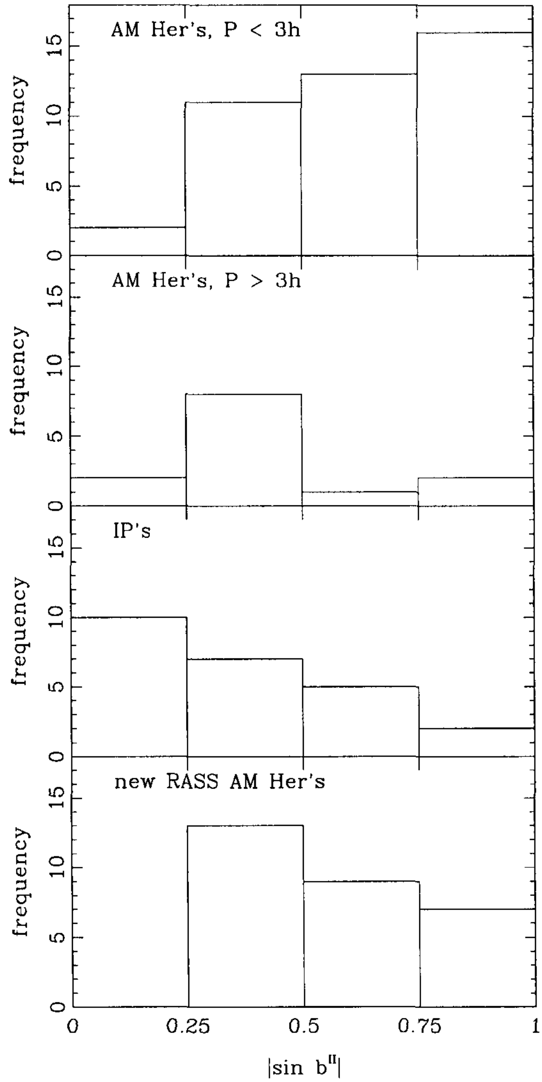

Fig. 2. Galactic latitude distributions of four subsets of magnetic cataclysmic variables: (i) short-period polars (AM Herculis binaries) with orbital period $P_{\rm orb} < 3\,\rm h$, (ii) long-period polars with orbital period $P_{\rm orb} > 3\,\rm h$, (iii) the subclass of intermediate polars (IPs), many of which possess harder X-ray spectra, and (iv) the polars newly discovered in the RASS. The lack of magnetic CVs at low Galactic latitudes is seen in all cases except that of the IPs. Derivation of the space density has to account for the severe Galactic absorption, therefore.

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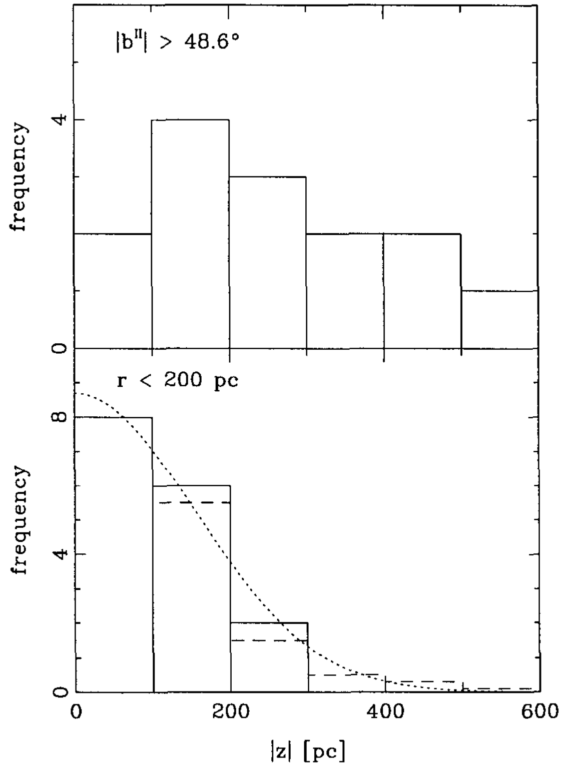

Fig. 3. *Upper panel:* The number of polars at high Galactic latitudes as a function of z. *Lower panel:* The number of polars within a cylinder of 200 pc radius perpendicular to the Galactic plane in intervals of 100 pc in $|z|$ (solid histogram). The same quantity for $|z| > 100$ pc as derived from the upper panel (dashed histogram). A Gaussion fit (dotted line) yields a standard deviation of $\sigma = 155$ pc.

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