# THE SOFT X-RAY BACKGROUND

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ABSTRACT

Maps in three energy bands from the recently-completed Wisconsin survey of the soft X-ray sky are presented. The lowest energy data require emission, almost certainly from hot interstellar gas, from regions within 100 pc of the sun. The data do not require diffuse emission from beyond the neutral galactic gas but are compatible with such emission under certain assumptions.

Soft X-rays of energy less than 1 keV come, with various intensities, from all directions including the galactic plane. Figures 1, 2 and 3 show the results of a recently-completed all-sky survey by the Wisconsin group using sounding rockets. The maps are in galactic coordinates and are for three energy bands defined as follows:

| | |
|---|---|
| B | 130-188 eV |
| C | 160-284 eV |
| M | 440-1100 eV |

The MIT group has recently completed the analysis of a survey in the C band using data from SAS-C and these results have been presented to this meeting by Dr. Clark. A comparison of their data and ours shows good agreement.

Figure 4 shows the distribution of HI column densities from the data of Cleary _et al_. (1979). The B and C band data are similar and both anticorrelate with the neutral gas. The M band distribution is unlike the distributions of the B and C bands and I shall discuss the M band data separately.

B and C band X-rays are readily absorbed by interstellar gas and there is no simple way that extragalactic or halo produced X-rays can account for the significant intensity in the galactic plane. Further, optical and ultra-violet absorption in the spectra of nearby stars (Cash, Bowyer and Lampton 1979, Bruhweiler and Kondo 1982) show that in the 100 or so parsecs near the solar system the mean neutral gas density is far below the galactic disk average, which is slightly more than 1 H atom/$cm^3$. For these reasons it is generally supposed that there exists a region of X-ray emission in the immediate 100 or so parsec vicinity of the solar system and that this region is responsible for



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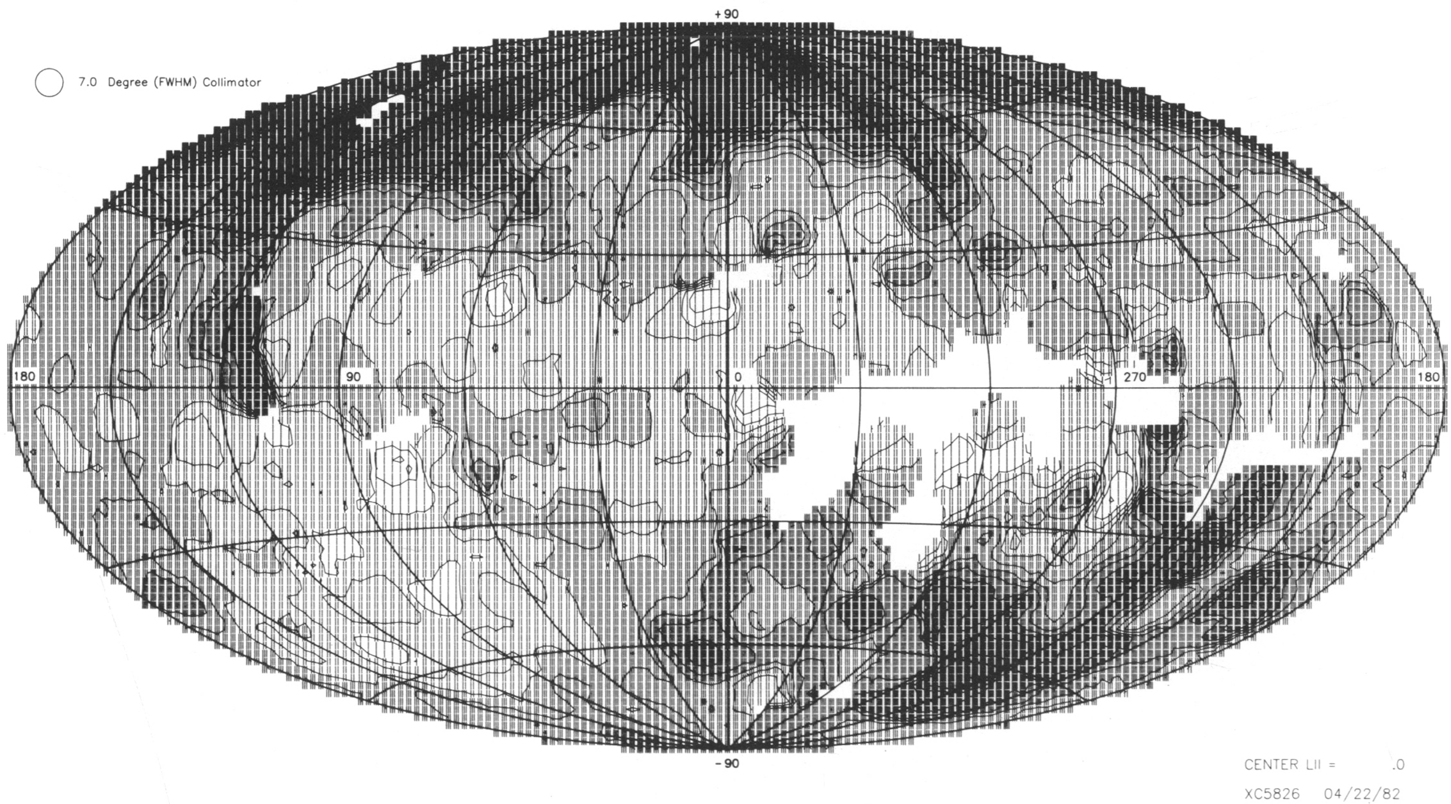


Figure 1. Galactic distribution of B band (130-188 eV) X-rays. Shading corresponds to 15 counts $sec^{-1}$ $line^{-1}$ in 4 square degree pixels.

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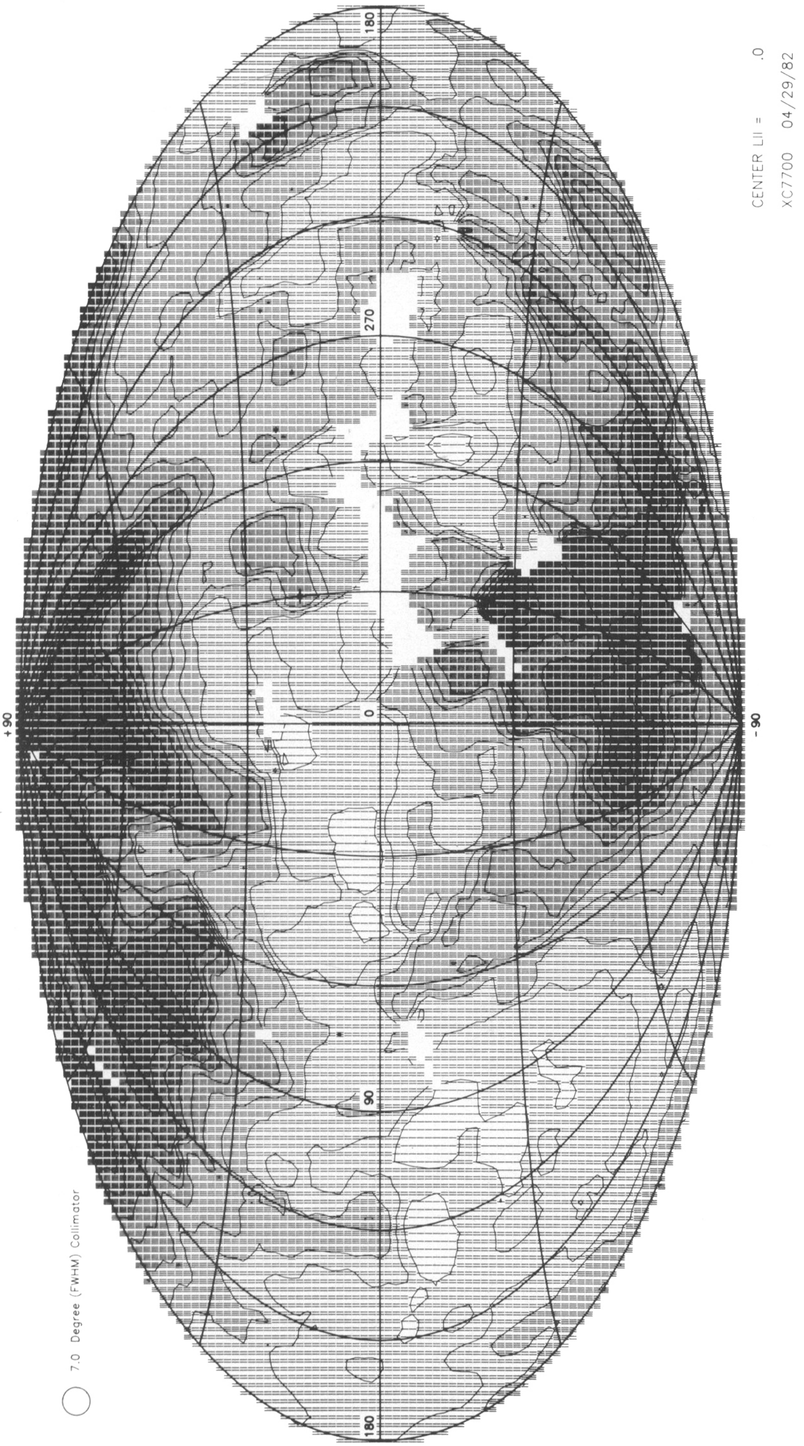


Figure 2. Galactic distribution of C band (160-284 eV) X-rays. Shading corresponds to 40 counts $sec^{-1}$ $line^{-1}$ in 4 square degree pixels.

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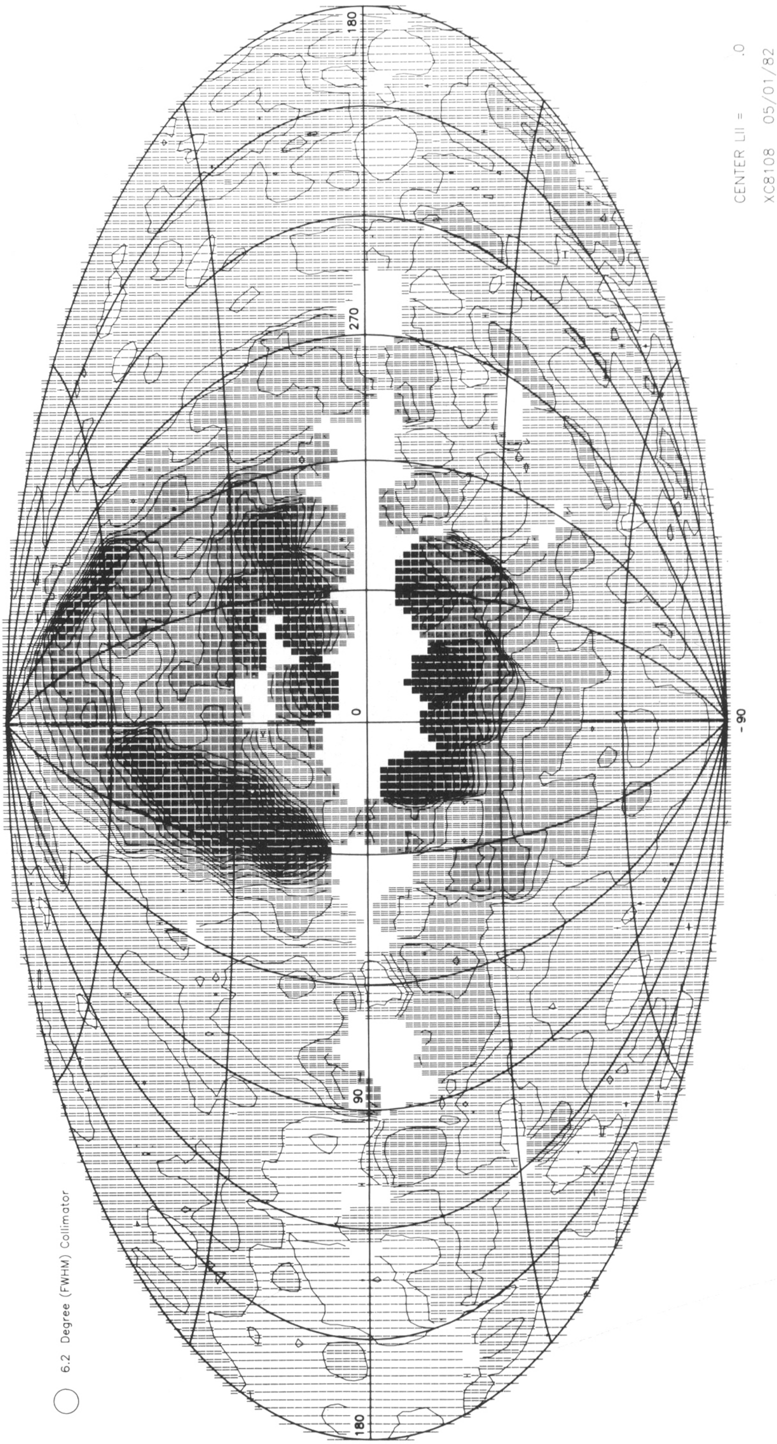


Figure 3. Galactic distribution of M band (440-1100 eV) X-rays. Shading corresponds to 25 counts $sec^{-1}$ $line^{-1}$ in 4 square degree pixels.

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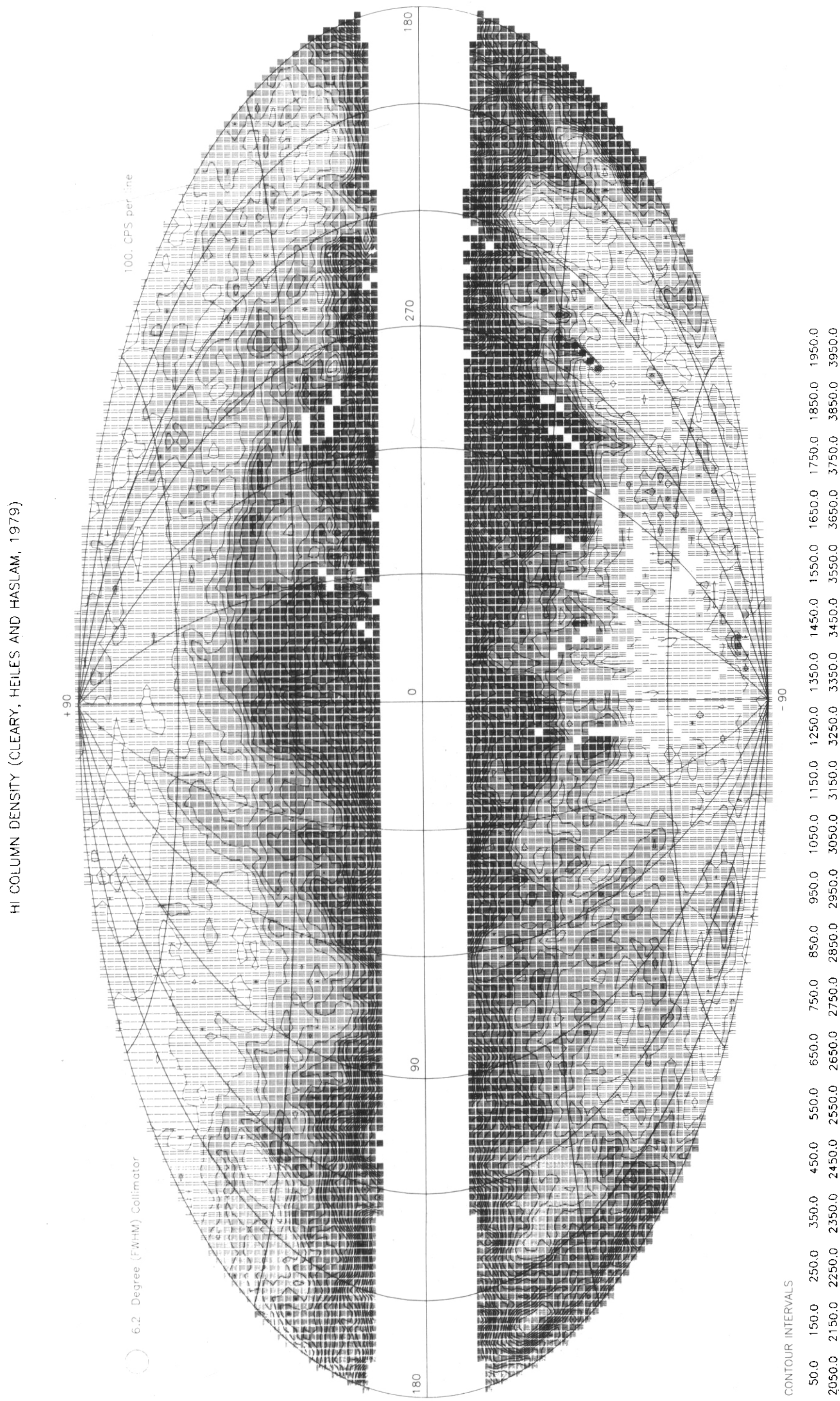


Figure 4. Galactic distribution of neutral hydrogen column density from Cleary, Heiles and Haslam (1979). Shading corresponds to $10^{20}$ atoms $cm^{-2}$ $\ell^{-1}$ in 4 square degree pixels.

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at least an appreciable fraction and possibly all of the detected radiation below 300 eV. The most important stellar source, M-dwarfs, contribute only a few percent to this low energy intensity, though M-dwarfs may well contribute 25% of the intensity measured at higher energies (Rosner et al. 1981).

Known non-thermal particles and processes cannot account for the observations (Williamson et al. 1974) and proportional counter data lead us to believe that the radiation results from line and continuum radiation from hot interstellar gas near $10^6$K. There is good evidence from the French - Danish group (Schnopper et al. 1982) and from the Japanese group (Inoue et al. 1979) that line radiation is present above 300 eV, but below 300 eV the existence of line radiation has not been demonstrated.

The required X-ray emissivity can be supplied by 100 pc of gas at $8 \times 10^5$K, provided the density is about $2 \times 10^{-3}$ $cm^{-3}$, putting the pressure at 3200 $cm^{-3}$K. This assumed normal abundance gas results in an OVI column density of $10^{13}$ $cm^{-3}$ and so is not in conflict with the Copernicus measurements (Jenkins and Meloy 1974, Jenkins 1978 a,b).

The marked tendency for diffuse X-rays in this energy region to decrease with increasing column density of atomic hydrogen was evident in the very early measurements (Bowyer, Field and Mack 1968, Bunner et al. 1969) and has been re-emphasized by Dr. Clark in his contribution. A natural interpretation in terms of absorption implies two emission components, one local and one remote. Only the remote source lies beyond the neutral galactic gas so that the intensity detected is

$$I = I_{local} + I_{remote}\, e^{-\sigma N}. \quad (1)$$

An important and possibly unjustified assumption here is that both $I_{local}$ and $I_{remote}$ are constant or at least do not vary in a systematic way with N, the column density of neutral gas. When this simple model is fit to the data, two parameters are determined

$$\frac{I_{remote}}{I_{local}} \simeq 2.5 \quad (2)$$

and

$$\sigma \simeq \frac{1}{3}\,\sigma\ \text{(laboratory)} \quad (3)$$

The only likely cause of a factor 3 reduction in the X-ray absorption cross section is gas clumping (Bowyer and Field 1969, Bunner et al. 1969). Clouds or non-uniform aggregates of interstellar gas, if optically thick in some places, leave other places relatively transparent. The required cloud thickness for a factor 3 reduction in cross-section is $N_c = 2.4 \times 10^{20}$ $cm^2$ if all the neutral gas is clumped. $N_c$ must be appreciably larger if some finite fraction of the neutral gas is diffuse. Available data on the HI spatial distribution do not support these extreme requirements.

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An alternative but physically less appealing explanation of the tendency for X-rays and neutral gas to anti-correlate is displacement (Sanders et al. 1977). By displacement is simply meant that hot X-ray emitting gas occupies volume which might otherwise be occupied by neutral gas. Hence an anti-correlation between X-rays and neutral gas follows.

Gas in the vicinity of $10^6$K can readily supply the observed X-rays below 300 eV, but falls far short of supplying the intensity in the M band, 440-1100 eV. The well-studied and presumably extragalactic high energy diffuse X-ray spectrum would contribute some 50% of the measured M band intensity if extrapolated down into this energy range. Einstein results indicate that another 25% or so of the M band intensity may come from M-dwarfs (Rosner et al. 1981). Both of these estimates are uncertain so it is less than clear that any M band X-rays originate in the general interstellar medium. Of course Loop I, the Cygnus Superbubble and certain other bright diffuse features do have M band emission.

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