IUE/IRAS STUDIES OF METAL ABUNDANCES AND INFRARED CIRRUS

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This paper reports on a survey of interstellar densities, abundances, and cloud structure in the Galaxy, using the IUE and IRAS satellites. We discuss heavy element depletions and their correlations with mean density, reddening, and galactic location. We also report on interesting correlations between the Fe/Si abundance ratio and the infrared diffuse cirrus, which may provide information on the history and formation of grains in the galactic halo.

From high-resolution (0.1 Å) IUE spectra we derive interstellar H I, Si II, and Fe II column densities toward 260 early-type stars by fitting the measured equivalent widths to single-component curves of growth. The IUE column densities of Fe II agree to 0.1 (dex), on average, with those derived by Copernicus (Jenkins, Savage, and Spitzer 1986) for 45 lines of sight in common. The good agreement depends critically on using consistent oscillator strengths and measuring the weak Fe II λ2260 line to fix the curve of growth. Without this line, IUE data systematically overestimates the doppler parameter (b) and underestimates the Fe II column density by 0.2 – 0.8 (dex), owing to the presence of high-velocity components in the wings of strong lines. The abundances of Fe, Si, and other refractory elements are enhanced in these components by shock processing of grains.

$\bar{n}$ [cm^{-3}]

Distance r [pc]
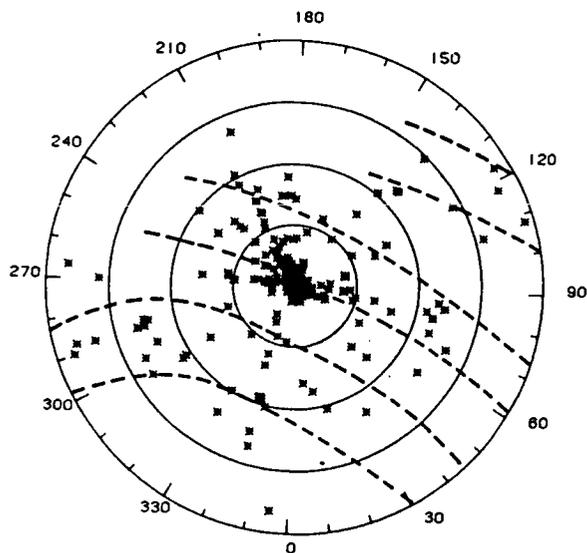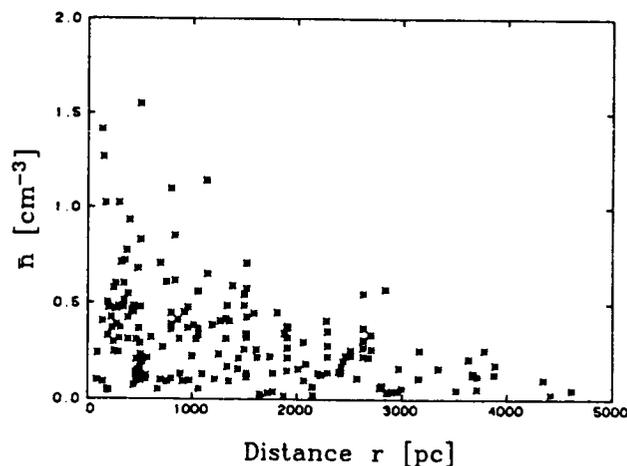
Figure 1   Figure 2

Figure 1 shows the 220 target stars in the statistical survey (B2.5 and earlier). The circular rings are 1 kpc apart and the dashed lines illustrate approximate locations of the spiral arms. Figure 2 shows the mean line-of-sight hydrogen density, $\bar{n} = N(H\ I)/r$, towards these stars. The distribution of $\bar{n}$ suggests an intercloud medium of density ~ 0.1 cm^{-3}. The survey averages are $\langle \bar{n} \rangle = 0.55$ cm^{-3} and $\langle N(H\ I)/E(B-V) \rangle = 5.2 \times 10^{21}$ cm^{-2} mag^{-1}. The vertical scale heights of H I, Si II, and Fe II are 144 ± 80 pc, 168 ± 90 pc, and 268 ± 100 pc, respectively.

Figure 3 shows the correlation of Si and Fe depletions with $\bar{n}$. This pattern is consistent with in-cloud depletion or with enhanced shock processing in low density regions. These and other data suggest that the intercloud medium contains a smoothly distributed component, of about 0.1 cm^{-3} density, in which heavy element depletions are considerably less than in the cloud cores.
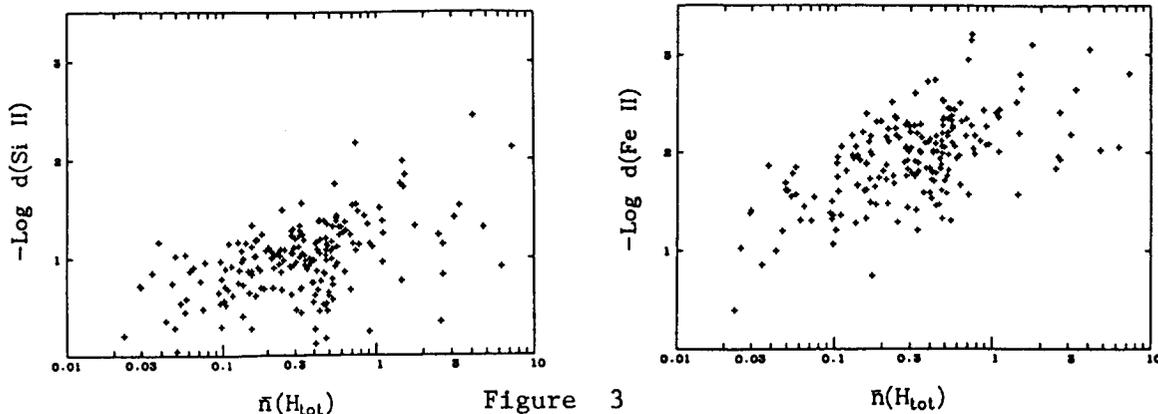
Figure 3

The Fe/Si ratio increases with galactic latitude (Fig. 4). The means are $\langle Fe/Si \rangle = 0.12$ in the disk (b < 20°) and 0.22 in the halo (b > 20°). This difference may result either from Fe-production from Type I supernovae in the halo or from differential shock destruction of iron-containing grains.
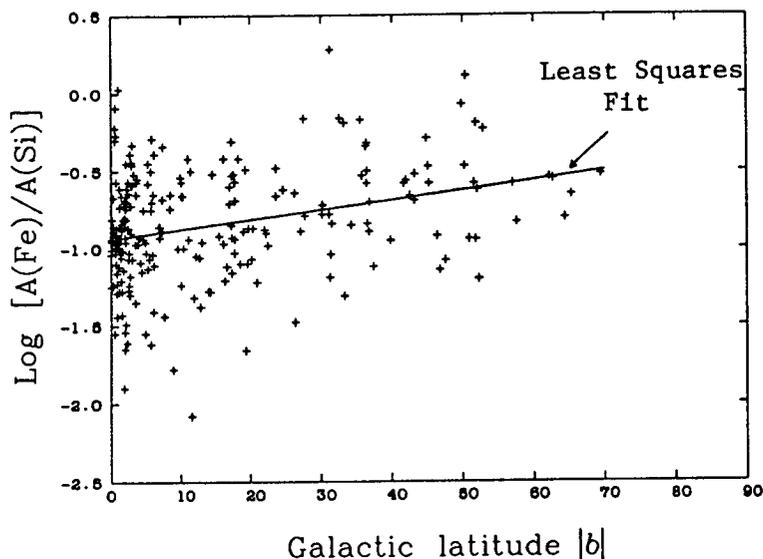
Fig. 4

Surprisingly, the Fe/Si ratio goes in the opposite sense with infrared diffuse cirrus, even for stars in the halo. We find increased Fe depletion and decreased Si depletion in lines of sight containing substantial 100 μm cirrus. Thus, although Fe/Si is generally higher in the halo, the ratio declines with increasing cirrus flux. The origin of this correlation is unknown. Several suggestions are:

(1) The grains in cirrus clouds are formed iron-rich and silicate-poor, because of the halo metal environment or seed-grain characteristics.

(2) The relative shock destruction of iron and silicate grains differ in the cirrus cloud and intercloud regions in the halo because of different shock propagation (speeds, ambient densities, shell sizes).