1. INTRODUCTION

There is an average Milky Way extinction relation, $A(\lambda)/A(V)$, over the wavelength range 0.125–3.5 $\mu$m, which is applicable to a wide range of interstellar dust environments, including lines of sight through diffuse dust and dark cloud dust, as well as dust associated with star formation (Cardelli, Clayton, & Mathis 1989, hereafter CCM; Cardelli & Clayton 1991; Mathis & Cardelli 1992; Fitzpatrick 1999). The existence of this relation, valid over a large wavelength interval, suggests that the environmental processes that modify the grains are efficient and affect all grains. The CCM relation depends on only one parameter, the ratio of total to selective extinction, $R_{V}$, which is a crude measure of the size distribution of interstellar dust grains.

However, the CCM relation does not appear to apply beyond the Milky Way. It does not always fit the observed extinction along sight lines observed in the Magellanic Clouds and M31 (e.g., Clayton & Martin 1985; Fitzpatrick 1985, 1986; Clayton et al. 1996; Bianchi et al. 1996; Gordon & Clayton 1998; Misselt, Clayton, & Gordon 1999). The 2175 $\AA$ bump is weaker and the far-UV extinction is steeper in many of the Magellanic Cloud sight lines, but there are also sight lines in both the LMC and SMC where the dust extinction does follow CCM. The few lines of sight studied in M31 seem to show a CCM-like far-UV extinction and a weak 2175 $\AA$ bump (Bianchi et al. 1996). On the other hand, the starburst nucleus of M33 appears to be associated with Milky Way–type dust (Gordon et al. 1999). The variations in extinction properties seen in the Magellanic Clouds and M31 may be due to several factors. Different environments, such as star formation regions where large amounts of UV radiation and shocks are present, may play a large role in processing dust. Evidence for this can be seen in the LMC, where two distinct wavelength dependences of UV extinction have been found for dust inside and outside the supernova remnants, and supernova explosions from the stellar association at its center (Misselt et al. 1999). In the SMC, the dust properties are even more extreme, showing extinction curves for three of four sight lines that have virtually no bump and are very steep in the far-UV (Gordon & Clayton 1998). Although the dust responsible for these curves is located near regions of star formation in the SMC, the environment is likely to be less severe than for the LMC 2 dust. The 30 Dor region, where LMC 2 is located, is a much larger star-forming region than any in the SMC. The dust environments in starburst galaxies and quasi-stellar objects (QSOs), which also show SMC-like extinction, are much more extreme than in 30 Dor (e.g., Gordon, Calzetti, & Witt 1997; Pitman, Clayton, & Gordon 2000; Gordon, Smith, & Clayton 2000). The SMC has star formation occurring at only 1% of the rate of a starburst galaxy, so other factors such as the known differences in metallicity between galaxies may be important (Fitzpatrick 1986; Gordon & Clayton 1998; Misselt et al. 1999).

Setting aside global metallicity differences, are there sight lines in the Galaxy where the dust environment is similar to those seen in the Magellanic Clouds? Real deviations from CCM are seen for a few sight lines in the Galaxy (Cardelli & Clayton 1991; Mathis & Cardelli 1992). The sight lines toward HD 62542, HD 204827, and HD 210121 show weak bumps and anomalously strong far-UV extinction for their measured values of $R_{V}$, but only HD 210121 shows deviations of the kind seen in the Magellanic Clouds. Their extinction curves are plotted in Figure 1. These deviant sight lines represent a variety of dust environments. The Galactic sight line toward HD 62542 is somewhat similar to...
Most of the Galactic sight lines that have been studied previously differ in one respect from the LMC and SMC sight lines: they are significantly more reddened than the Magellanic Cloud sight lines. In particular, the sight lines showing the greatest deviations from CCM, those near the supershell LMC 2 and those in the SMC, all have $E(B-V) < 0.25$. Of the 29 CCM sight lines only two have $E(B-V) < 0.30$. The others range up to $E(B-V) = 1.2$. Similarly, the Fitzpatrick & Massa sample of 80 stars includes only seven with $E(B-V) < 0.30$ (Fitzpatrick & Massa 1990, hereafter FM90; Fitzpatrick 1999). Therefore, the dust along the Magellanic Cloud sight lines is more diffuse and more representative of the warm intercloud medium than the cold cloud medium, which is better represented in the Galactic samples.

Kiszko-Nkozij & Lequeux (1987) suggest from Astronomical Netherlands Satellite extinction measurements of 1200 stars in the Galaxy that there may be a correlation between UV extinction parameters and distance from the Galactic plane. As $|z|$ increases, the bump becomes weaker and the far-UV extinction stronger. These sight lines have low reddenings and long sight lines, so they are also more diffuse and therefore more like those in the Magellanic Clouds.

LMC 2. Its dust was swept up by bubbles blown by two nearby O stars (Cardelli & Savage 1988). HD 204827 is also in a star formation region where the dust has been subject to shocks (Clayton & Fitzpatrick 1987). HD 210121 lies behind a single cloud in the halo. There is no present activity near this cloud, although it was ejected into the halo at some time in the past. There are some important differences between these Galactic extinction curves and those in the Magellanic Clouds. The bump seen for HD 62542 is not just weak but is very broad and shifted to the blue (Cardelli & Savage 1988). Mantles on the bump grains have been suggested as the reason for the weak, broad, and shifted Galactic bumps (Mathis & Cardelli 1992; Mathis 1994). These sight lines show that dust in a variety of environments with a range of $R_V$ values can have extinction curves similar to those in the LMC. However, none of the anomalous Galactic sight lines, seen in Figure 1, approach the SMC extinction properties. The SMC dust has weaker bumps and steeper far-UV extinction than any known Galactic or LMC sight line.

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**TABLE 1**

LOW DENSITY INTERSTELLAR SIGHT LINES IN THE GALAXY

| HD     | Spectral Type | $V$  | $E(B-V)$ | $l$ (deg) | $b$ (deg) | $d$ (kpc) | $z$ (kpc) | Type | $n_H$ (H I) | $N$(Ca ii)/$N$(Na i) |
|--------|---------------|------|----------|-----------|-----------|-----------|-----------|------|-------------|----------------------|
| 64219  | B2.5 III      | 9.72 | 0.17     | 241.99    | 0.94      | 3.46      | 0.06      | IA1  | 0.098       | 0.49                 |
| 69106  | B0.5 I Vm     | 7.13 | 0.18     | 254.52    | -1.33     | 1.49      | -0.03     | IA1  | 0.235       | 0.21                 |
| 93827  | B1 I b        | 9.31 | 0.23     | 288.55    | -1.54     | 8.31      | -0.22     | IA2  | 0.064       | 0.45                 |
| 94493  | B1 I b        | 7.23 | 0.20     | 289.01    | -1.18     | 3.33      | -0.07     | IA1  | 0.121       | 0.66                 |
| 97848  | O8 V          | 8.68 | 0.30     | 300.74    | 1.53      | 2.69      | 0.09      | IA2  | 0.225       | 0.50                 |
| 100276 | B0.5 I b      | 7.16 | 0.26     | 293.31    | 0.77      | 2.96      | 0.04      | IA2  | 0.172       | 0.38                 |
| 103779 | B0.5 I ab     | 7.20 | 0.21     | 296.85    | -1.02     | 4.02      | -0.07     | IA2  | 0.225       | 0.50                 |
| 104683 | B1 I b        | 7.92 | 0.19     | 297.74    | -1.97     | 4.64      | -0.16     | IA2  | 0.090       | 0.79                 |
| 104705 | B0 I b        | 7.76 | 0.26     | 297.45    | -0.34     | 3.90      | -0.02     | IA2  | 0.128       | 0.67                 |
| 113012 | B0.2 I b      | 8.12 | 0.34     | 304.21    | 2.77      | 4.11      | 0.20      | IA2  | 0.188       | 0.50                 |
| 148422 | B1 I a        | 8.60 | 0.28     | 329.92    | -5.60     | 8.84      | -0.86     | GC   | 0.125       | 0.72                 |
| 151805 | B1 I b        | 8.91 | 0.32     | 343.20    | 1.59      | 5.94      | 0.16      | IGC  | 0.119       | 0.34                 |
| 151990 | O9 IV         | 9.46 | 0.39     | 334.99    | -5.54     | 4.47      | -0.43     | GC   | 0.244       | 0.69                 |
| 158224 | B1 I ab:      | 8.15 | 0.19     | 337.59    | -10.64    | 6.49      | -1.20     | IGC  | 0.145       | 0.63                 |
| 160993 | B1 I ab:      | 7.73 | 0.21     | 345.61    | -8.56     | 5.20      | -0.77     | IGC  | 0.149       | 0.63                 |
| 161653 | B1 I         | 7.11 | 0.26     | 352.42    | -5.26     | 1.82      | -0.17     | IA2  | 0.315       | ...                 |
| 163522 | B1 I a        | 8.46 | 0.19     | 349.57    | -9.09     | 9.42      | -1.49     | IGC  | 0.119       | 1.11                 |
| 164019 | O9.5 III      | 9.26 | 0.53     | 1.91      | -2.62     | 3.83      | -0.28     | GC   | 0.308       | ...                 |
| 164340 | B0.2 I II     | 9.25 | 0.15     | 352.06    | -8.60     | 5.46      | -0.82     | IGC  | 0.105       | 0.95                 |
| 165582 | B1 II         | 9.33 | 0.24     | 357.49    | -6.96     | 5.21      | -0.63     | IGC  | 0.152       | 0.85                 |
| 167402 | B0 I b        | 8.95 | 0.23     | 2.26      | -6.39     | 7.04      | -0.78     | IGC  | 0.121       | 0.79                 |
| 168941 | O9.5 II–III   | 9.34 | 0.37     | 5.82      | -6.31     | 5.79      | -0.64     | IGC  | 0.212       | <0.38                |
| 172140 | B0.5 III      | 9.96 | 0.22     | 5.28      | -10.61    | 6.85      | -1.26     | IGC  | 0.165       | 0.82                 |
| 177989 | B0 III        | 9.33 | 0.25     | 17.81     | -11.88    | 4.91      | -1.01     | GC   | 0.223       | <0.25                |
| 178487 | B0 I a        | 8.66 | 0.40     | 25.78     | -8.56     | 7.66      | -1.14     | IGC  | 0.249       | <0.31                |
| 179407 | B0.5 I b      | 9.41 | 0.31     | 24.02     | -10.40    | 7.76      | -1.40     | IGC  | 0.224       | <0.39                |

**Fig. 1.**—Sight lines in the Galaxy showing anomalous extinction. CCM curves for $R_V$ values of 2.5 and 3.1 are plotted for comparison.
Clouds. To investigate whether the extinction properties observed in the Magellanic Clouds are related to the diffuse nature of the sight lines, a sample of long sight lines with low redshiftings in the Galaxy was chosen and UV data were obtained with the International Ultraviolet Explorer (IUE) so that extinction curves could be constructed.

2. THE SAMPLE

Sembach, Danks, & Savage (1993) obtained high-resolution Na I D and Ca II K spectra for a sample of distant \((d > 1 \text{ kpc})\) stars. These sight lines were selected to investigate the distribution and physical conditions of gas located in low-density regions of the Galactic disk and halo. The sight lines listed in Table 1 were selected from the Sembach et al. (1993) sample for a complementary study of the UV extinction properties of interstellar dust in low-density conditions. The Sembach et al. (1993) sample is limited to stars with spectral types between O8 and B3, which makes them ideal for extinction studies. Following the definitions of Sembach et al. (1993), the sight lines in Table 1 lie outside the Sagittarius spiral arm (IA1), between the Sagittarius and Scutum-Crux spiral arms (IA2), beyond the Scutum-Crux arm toward the Galactic center (GC), and within the inner 4 kpc of the Galaxy (IGC). The stars lie at the Scutum-Crux arm toward the Galactic center (GC), and the Sagittarius and Scutum-Crux spiral arms (IA2), beyond the Scutum-Crux arm toward the Galactic center (GC), and within the inner 4 kpc of the Galaxy (IGC). The stars lie at distances ranging from 1.5 to 9.5 kpc and have heights above or below the plane of 0–1.5 kpc. Twelve of the sight lines extend into the Galactic halo, defined as \(|z| > 500 \text{ pc}\). The locations of these stars in the Galaxy are plotted in Figure 1 of Sembach et al. (1993).

3. EXTINCTION CURVES

Low-dispersion short- and long-wavelength IUE spectra were obtained between 1991 and 1994 by Jason Cardelli. The spectra listed in Table 2 were downloaded from the IUE archive. The archive spectra were reduced using NEWSIPS and then were recalibrated using the method developed by Massa & Fitzpatrick (2000). The short- and long-wavelength spectra for each star were co-added, binned to the instrumental resolution \((\sim 5 \text{ Å})\), and merged at the maximum wavelength of the short-wavelength spectrum.

Extinction curves were constructed using the standard pair method (e.g., Massa, Savage, & Fitzpatrick 1983). Uncertainties in the extinction curves contain terms that depend on both the broadband photometric uncertainties and those in the IUE fluxes, which are calculated directly in NEWSIPS. Our error analysis is described in detail in Gordon & Clayton (1998). The sample includes early-type supergiants that may be used with the same accuracy as main-sequence stars in calculating extinction (Cardelli, Sembach, & Mathis 1992). We required \(\Delta(B-V) > 0.14\) between the reddened and comparison stars to minimize the uncertainties. The comparison stars have been dereddened as described by Cardelli et al. (1992). Table 1 lists a value of \(E(B-V)\) for each star from Sembach et al. (1993). Table 2 lists the \(\Delta(B-V)\) between the measured \((B-V)\) of the reddened star and the \((B-V)\) of the best-match dereddened comparison star. The extinction curves for the sample stars are shown in Figure 2.

The extinction curves have been fitted using the FM90 parameterization. They have developed an analytical representation of the shape of the extinction curves using a small number of parameters. This was done using linear combinations of a Drude bump profile, \(D(x; \gamma, x_0)\), a linear background, and a far-UV curvature function, \(F(x)\), where \(x = \lambda^{-1}\). There are six parameters determined in the fit: the

| Star (HD) | Standard (HD) | Spectral Type | \(\Delta(B-V)\) | SWP Spectra | LWR/LWP Spectra |
|----------|---------------|--------------|-----------------|-------------|-----------------|
| 64219……..| 31726         | B1 V         | 0.20            | SWP 47546   | LWR 25410/25412 |
| 69106……..| 63922         | B0 III       | 0.21            | SWP 11114/47547   | LWR 8825 |
| 93827……..| 62747         | B1.5 III     | 0.29            | SWP 48392/48400 | LWP 26160 |
| 94493……..| 119159        | B0.5 III     | 0.29            | SWP 47548/47571 | LWP 25413/25420 |
| 97484……..| 47839         | O7 V         | 0.29            | SWP 39231   | LWP 18380 |
| 100276…….| 64760         | B0.5 Ia      | 0.25            | SWP 39256   | LWP 18397 |
| 103779…….| 64760         | B0.5 Ia      | 0.22            | SWP 48391/48399 | LWP 26159/26170 |
| 104683…….| 119159        | B0.5 III     | 0.28            | SWP 47560   | LWP 25414/25424 |
| 104705…….| 63922         | B0 III       | 0.28            | SWP 39257   | LWP 18398 |
| 113012…….| 63922         | B0 III       | 0.41            | SWP 47559   | LWP 25423 |
| 148422…….| 64760         | B0.5 Ia      | 0.30            | SWP 48329   | LWP 26100 |
| 151805…….| 40111         | B1 Ia        | 0.34            | SWP 39267   | LWP 18408 |
| 151990…….| 188209        | O9.5 Ia      | 0.34            | SWP 47555/47570 | LWP 25419 |
| 158243…….| 91316         | B1 Iab       | 0.19            | SWP 48328   | LWP 26099 |
| 160993…….| 40111         | B1 Ia        | 0.21            | SWP 48334   | LWP 26105/26109 |
| 161653…….| 62747         | B1.5 III     | 0.25            | SWP 47542   | LWP 25406 |
| 163522…….| 91316         | B1 Iab       | 0.19            | SWP 48335   | LWP 26106 |
| 164019…….| 167756        | B0 Ia        | 0.45            | SWP 33407/47543 | LWP 13140/13141/25416/25417 |
| 164340…….| 119159        | B0.5 III     | 0.14            | SWP 47541/47552 | LWP 25441 |
| 165582…….| 119159        | B0.5 III     | 0.28            | SWP 48336   | LWP 26107 |
| 167402…….| 167756        | B0 Ia        | 0.20            | SWP 42336   | LWP 21095 |
| 168941…….| 63922         | B0 III       | 0.34            | SWP 33409/47540 | LWP 13142/25404 |
| 172140…….| 119159        | B0.5 III     | 0.24            | SWP 48341   | LWP 26110/26172 |
| 177989…….| 119159        | B0.5 III     | 0.23            | SWP 42342   | LWP 21110 |
| 178487…….| 167756        | B0 Ia        | 0.38            | SWP 48415/48415 | LWP 26186 |
| 179407…….| 150168        | B1 Ia        | 0.28            | SWP 42334   | LWP 21093/21096 |
strength, central wavelength, and width of the bump, $c_3$, $x_0$, and $\gamma$; the slope and intercept of the linear background, $c_1$ and $c_2$; and the strength of the far-UV curvature, $c_4$. The FM90 fits to individual extinction curves are plotted in Figure 2, and the best-fit parameters for each curve are given in Table 3.

Near-infrared photometry exists for a few of the reddened stars in our sample. For these stars, using $JHK$ photometry, we calculated values of $R_V$. Because of the small values of $E(B-V)$ for our sample stars, the uncertainties in $R_V$ are relatively large. Within these uncertainties, most are consistent with the typical diffuse dust value of 3.1. There is no
trend with position on the sky discernible with the small number of sight lines having measured $R_v$ values.

4. DISCUSSION

The sight lines in our sample cover very long distances and have relatively low reddenings, so the average densities are among the lowest known (Sembach et al. 1993). The measured values for $n_0(H\text{I})$ [$= N(H\text{I}) \sin |b|/h(H\text{I})$], where $h(H\text{I})$ is the scale height of $H\text{I}$, are listed in Table 1. The parameter $n_0(H\text{I})$ is a measure of average density along a sight line (Sembach et al. 1993). Typically, when $n_0(H\text{I}) < 0.42$ cm$^{-3}$, no large cold clouds are present along the line of sight (Sembach et al. 1993). All of the stars in Table 1 satisfy this criterion. In addition, the warm intercloud medium dominates over the diffuse cold cloud medium if $n_0(H\text{I}) < 0.2$ cm$^{-3}$. Most of the stars in Table 1 satisfy this criterion or come close to it. The ratio of the column density of Ca II to Na I, also listed in Table 1, is another measure of the relative contributions of cloud and intercloud medium. Na I is relatively stronger in clouds, while Ca II is relatively strong in the diffuse interstellar medium (ISM). This is due to the strong variation in the calcium depletion from the gas phase into dust grains (Sembach & Danks 1994; Crinklaw, Federman, & Joseph 1994). The depletion is higher inside clouds and lower outside where the harsher environment including sputtering and grain collisions will return calcium
to the gas phase. The wide range in $N(\text{Ca II})/N(\text{Na I})$ indicates that the cloud/intercloud fraction varies strongly from one sight line to another. The absorption features along these lines of sight show multiple components indicating that the distribution of gas is patchy. The average number of components or clouds is 1.5 kpc$^{-1}$ for Na I and 2.0 kpc$^{-1}$ for Ca II (hereafter the SD region; Sembach & Danks 1994). Using these values and the measured reddening, the average $E(B - V)$ per cloud is 0.05 mag, which is typical for standard diffuse clouds (Spitzer 1978). Similarly, the average H I column density per cloud is $2.3 \times 10^{20}$ cm$^{-2}$. It is likely that most of these sight lines are dominated by the warm intercloud medium and have little contribution from the cold cloud medium.

Figure 2 shows that even for extremely diffuse sight lines such as those in our sample, most extinction curves still follow CCM with $R_V = 3.1$. However, there is a subsample of these sight lines whose extinction curves show weak bumps and very steep far-UV extinction similar to the Magellanic Clouds. These sight lines all lie in one region of the sky in the direction of the Galactic center. This region (SD) coincides with an area of Galactic longitude, $l = 325^\circ - 0^\circ$, where large forbidden velocities have been observed in the gas. Figure 3 shows bump strength plotted against...
far-UV steepness for our sample extinction curves. The bump strength can be quantified as the area under the bump taking the FM90 parameters to be $\pi c_3/2\gamma$ (Fitzpatrick & Massa 1986). The steepness of the far-UV extinction can be characterized using the FM90 parameter, $c_2$, which represents the slope of the linear background. Seven of the nine sight lines lying in the SD region have the largest values of $c_2$ in our sample. Six of these sight lines also have bump strengths below the Galactic average. The sight lines in our sample outside the SD region have values of bump strength and $c_2$ grouped around the Galactic average. As can be seen in Figure 3, the SD region extinction parameters fall roughly along a line running from the average Galactic values through the LMC and LMC 2 averages to those seen in the SMC. This is a promising result, as it indicates that whatever factors are affecting the dust properties in the Magellanic Clouds may also be affecting the low-density dust in the Milky Way. As discussed below, the two SD region stars that appear in the upper left-hand corner of Figure 3 do not share the extinction properties of the rest of the SD region sample.

The locations of the stars in our sample are plotted in Figure 4. We have separated sight lines according to the steepness of the far-UV extinction as measured by $c_2$ and
also the ratio \( N(\text{Ca II})/N(\text{Na i}) \), which measures the relative fraction of cloud and intercloud medium along a sight line. A high value indicates a high fraction of intercloud medium. All of the sight lines in Table 1 with both \( N(\text{Ca II})/N(\text{Na i}) > 0.62 \) and \( c_2 > 1.02 \) lie in the SD region. Figure 5 shows height above or below the Galactic plane plotted against distance in the plane for the stars in the SD region. Figures 4 and 5 clearly show that the anomalous extinction is seen only for stars in one particular direction. The two stars in the SD region that do not share the anomalous extinction of the other sight lines provide information on the location of this dust. HD 151805 has \( b = 1^\circ.59 \), so its sight line does not go below the Galactic plane as do the other stars in the sample. HD 161653 lies at a distance of 1.8 kpc and is, by far, the closest star in the \( l = 325^\circ-0^\circ \) region. So the dust responsible for the Magellanic Cloud-like extinction lies farther than about 2 kpc and in a direction defined by \( 325^\circ \leq l \leq 0^\circ \) and \(-5^\circ \geq b \geq -11^\circ \). In fact, the four sight lines with the steepest extinction, HD 158243, HD 160993, HD 163522,

![Figure 2](image-url)
Fig. 3.—Steepness of the far-UV extinction ($c_2$) plotted against bump strength ($\kappa c_2/2\gamma$) for the stars in the SD region lying between $l = 325^\circ$ and $0^\circ$ (*filled circles*) and for those of the rest of the sample (*open circles*). Also, plotted from upper left to lower right are average points (*filled squares*) for the Galaxy, LMC (outside LMC 2), LMC 2, and SMC (Misselt et al. 1999; Gordon & Clayton 1998).

and HD 164340, most resembling the SMC extinction, lie in an even smaller region bounded by $337^\circ \leq l \leq 352^\circ$ and $-8^\circ \geq b \geq -11^\circ$. These four stars also have the lowest reddenings. So the remaining three less extreme sight lines are likely a combination of clouds including more CCM-like dust as well. Kennedy, Bates, & Kemp (1998) give a nice analysis of the absorption components in this direction of the sky, including the sight line to HD 163522 ($l = 349^\circ 6$, $b = -9^\circ 1$, $d = 9.4$ kpc). In their picture, nearby clouds at 50 pc, 100 to 1 kpc, the Sagittarius ($1.5$–$2$ kpc) and Scutum-Crux ($3$ kpc) spiral arms all provide absorption components with negative or small positive velocities. They identify peculiar velocity gas corresponding to the forbidden velocities of $10$–$50$ km s$^{-1}$ found by Sembach & Danks (1994). These forbidden velocities differ significantly from those expected purely from Galactic rotation. The origin and distance of this gas is not well known. Higher ionization ions are associated with this gas, indicating that it may be associated with a Galactic fountain or worm (Savage, Massa, & Sembach 1990; Savage, Sembach, & Cardelli 1994).

The extinction curves for the sight lines inside and outside the SD region are plotted together in Figure 6. Two sight lines, toward HD 151805 and HD 161653, in the SD region show normal CCM ($R_V = 3.1$) extinction. As discussed above, the dust along those sight lines is not located in the same volume of space as the SD-type dust, so they are plotted with the non–SD region sample in Figure 6. The average SD region curve (again not including HD 151805 and HD 161653) is plotted in Figure 7 along with the average Milky Way and Magellanic Cloud curves for comparison. The average SD region curve most resembles the HD 62542 and HD 210121 curves, seen in Figure 1, as well as the LMC 2 curve. The four steepest SD region curves resemble the SMC bar curve in the far-UV but still have stronger bump strengths. These curves show little or no slope change from the near-UV to the far-UV, while most other curves seen in Figures 1 and 7 tend to turn up steeply to the blue of the bump.

The environments of the LMC 2 and HD 62542 dust may be quite similar to the SD region dust. All are in diffuse regions subject to shocks and strong UV radiation fields. The sight line to HD 210121 contains one quiescent cloud with $E(B-V) = 0.40$. However, this cloud is located in the halo and shows UV extinction quite similar to that seen in the SD region. Calcium is heavily depleted, indicating that grain destruction has not been an important mechanism in

Fig. 4.—Positions of the stars in our sample in the plane of the Galaxy are plotted with respect to the Sun and the Galactic center. Sight lines marked with circles have weak bumps and steep far-UV extinction. The sight lines marked with squares have stronger bumps and less extreme far-UV extinction. Filled circles have $N(Ca\emph{ii})/N(Na\emph{ii}) > 0.62$ and $c_2 > 1.0$, open circles have $N(Ca\emph{ii})/N(Na\emph{ii}) < 0.63$ and $c_2 > 1.0$, filled squares have $N(Ca\emph{ii})/N(Na\emph{ii}) > 0.62$ and $c_2 < 1.0$, and open squares have $N(Ca\emph{ii})/N(Na\emph{ii}) < 0.63$ and $c_2 < 1.0$. The wedge represents the SD region where forbidden gas velocities were measured by Sembach & Danks (1994).

Fig. 5.—Height above or below the Galactic plane plotted against distance in the plane for the stars in the SD region in Fig. 4. The symbols are the same as for Fig. 4. The wedge contains the region in which anomalous dust extinction has been found.

The environments of the LMC 2 and HD 62542 dust may be quite similar to the SD region dust. All are in diffuse regions subject to shocks and strong UV radiation fields. The sight line to HD 210121 contains one quiescent cloud with $E(B-V) = 0.40$. However, this cloud is located in the halo and shows UV extinction quite similar to that seen in the SD region. Calcium is heavily depleted, indicating that grain destruction has not been an important mechanism in
producing the unusual extinction (Welty & Fowler 1992). The low optical depth of the Magellanic sight lines implies that the dust is not well shielded from these environmental pressures. The typical molecular cloud in the Magellanic Clouds is bigger but more diffuse than in the Galaxy (Pak et al. 1998). Then, the small size of the dust grains in a cloud could be the result of the lack of a very dense environment necessary for the grains to grow through coagulation. This has been suggested as the cause of the anomalous extinction seen along the HD 210121 sight line (Larson, Whitsett, & Hough 1996; Larson et al. 2000). This kind of low-density sight line may mimic the conditions in the SMC where extinction properties have been measured over long sight lines with low values of $E(B-V) = 0.15$–0.24 (Gordon & Clayton 1998). The value of $N$(Ca II)/$N$(Na I) is not known for the SMC sight lines, but the Ca II abundance in the gas phase is much higher than in the Galaxy for a given reddening (Cohen 1984). The gas-to-dust ratio in general in the SMC is 10 times that of the Galaxy (Koornneef 1983). The gas-to-dust ratio in our low-density Galactic sample is not significantly different from the average Galactic value (Sembach & Danks 1994). This implies that the gas-to-dust ratio is not well correlated with dust extinction properties.

The forbidden velocities seen in our sample are associated with warm intercloud material and the turbulent ISM (Sembach & Danks 1994) and may indicate that the dust might have been subject to shocks. Sembach & Savage (1996) investigated the gas and dust abundances in the halo, finding that they are consistent with progressively more severe processing of grains from the disc into the halo. In addition, they find that while some material is returned to the gas phase, the grain cores seem resistant to destruction. Dust models indicate that the far-UV rise in the extinction curve becomes steeper with increased frequency of exposure to shocks, which produces more small dust grains (ODonnell & Mathis 1997). However, the frequently shocked dust models that produce steeper far-UV extinction also result in stronger bumps. Thus, producing an SMC-like extinction curve is not as simple as placing dust in a diffuse environment and waiting for a supernova shock.

The next logical step is to attempt to connect grain properties directly to their respective sight-line environments. Consequently, we have included the average SD region extinction curve in a comprehensive study of dust in the Local Group, where our goal is to explicitly examine the correlation of grain-size distributions to sight-line characteristics such as depletion patterns and radiation environment (Wolff, Clayton, & Gordon 2000).

5. CONCLUSIONS

1. Magellanic Cloud–like extinction has now been found in the Milky Way.
2. Large values of $N$(Ca II)/$N$(Na I) indicating low depletion are associated with steep far-UV extinction as measured by $c_2$.
3. Global metallicity seems not to be a direct factor. Local environmental conditions seem to be the most important factor in determining dust properties.
4. Similar UV dust extinction properties have now been seen in the Milky Way, Magellanic Clouds, starburst galaxies, and high-redshift star-forming galaxies.
5. There may be at least two ways to achieve similar extinction properties. A lack of dust coagulation has been suggested for HD 210121 to explain the observed extinction (Larson et al. 1996). The Galactic SD region properties are closely tied to forbidden velocities, indicating that pro-
cessing of the grains in the diffuse ISM resulted in their observed properties.

6. There seems to be a correlation between decreasing bump strength and far-UV steepness that includes the Galaxy and the Magellanic Clouds.

7. All the sight lines contained in CCM lie within 1 kpc of the Sun. As this study shows, dust properties are not well mapped even in our own Galaxy. There is a larger range of UV extinction parameters seen in the Milky Way than implied by CCM.

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