

A COMPILATION OF INTERSTELLAR COLUMN DENSITIES

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ABSTRACT

We have collated absorption line data toward 3008 stars in order to create a unified database of interstellar column densities. These data have been taken from a number of different published sources and include many different species and ionizations. The preliminary results from our analysis show a tight relation $[N(\text{H})/E(B-V) = 6.12 \times 10^{21}]$ between $N(\text{H})$ and $E(B-V)$. Similar plots have been obtained with many different species, and their correlations along with the correlation coefficients are presented.

Key words: dust, extinction – ISM: abundances – ISM: clouds

Online-only material: color figures, machine-readable tables

1. INTRODUCTION

Over the past few decades, a great effort has been made to better understand the structure, dynamics, and physical conditions of the interstellar medium (ISM; reviewed by Cox 2005). Much of this information has come through absorption line spectroscopy, and Fruscione et al. (1994) compiled a comprehensive list of the data available at the time. Their original purpose was to guide observations for the *Extreme Ultraviolet Explorer* (EUVE), but their data have since been used for many other purposes, including three-dimensional maps of the ISM (Lallemand et al. 2003).

There are now many more observations from both space-based (e.g., Savage & Lehner 2006) and ground-based telescopes (Welty & Crowther 2010), which we have compiled into a single database. Our primary goal in this work is to make these data accessible to a larger community as a tool for estimating the distribution of gas and dust in our Galaxy. Although we have taken pains to ensure that this work is as complete as possible, we will still have missed some published data. We intend to continually update our compilation with the latest version always available from the authors directly.

2. DATA AND DISCUSSION

We have searched through the literature for absorption line measurements of interstellar lines and have found a total of 3008 sight lines with existing observations (Figure 1). We have tabulated these observations in Table 1, including the coordinates, spectral type and distance of each star, and the column density of each species observed along that line of sight. Many sight lines had multiple observations, and we consistently selected the last published and listed those in Table 2, which is a subset of Table 1. Details of each column in Tables 1 and 2 are listed in the Appendix. The complete reference list is tabulated in Table 3. The identifying number for each reference from this table is given in brackets at the end of each paper’s alphabetical listing in the References section of this paper. All three tables are available in full in the online version with samples published here.

One of four methods has been used in the literature to derive the column densities from the observed observation lines: “curve of growth (COG)”; “apparent optical depth (AOD)”; “profile

fitting (PF)”; and “continuum reconstruction.” We briefly visit these methods in the following paragraphs.

The COG is a graph showing how the equivalent width of an absorption line increases with the number of atoms producing the line. In optically thin gas, the equivalent width is linearly proportional to the number of atoms in the initial level of the line (linear part of the curve). When the line saturates, the equivalent width barely changes with further increase in number of atoms (logarithmic part of the curve or Doppler plateau). Most absorption lines lie in this regime where it is difficult to estimate the equivalent width reliably. In an optically thick gas, the wings of the profile contribute to a rather slow increase in the equivalent width (square root part or damping part of the curve; Lequeux et al. 2005). The COG method is most useful when multiple lines of a single species are observed and the instrumental resolution is not sufficient for detailed PF, as was the case in most lines observed by the *International Ultraviolet Explorer* (IUE; e.g., van Steenberg & Shull 1988).

In the AOD technique, the column density is determined by directly integrating the apparent column density profile over the velocity range of the absorption profile. This integrated apparent column density is equivalent to the actual column density provided that the line is not saturated and optical depth is less than 1 (Williger et al. 2005). The AOD technique offers a quick and convenient way of determining reliable interstellar column densities from unsaturated lines without having to follow a full COG analysis or detailed component fit and without demanding prior knowledge of the component structure. This method has gained substantial popularity as a means of converting velocity-resolved flux profiles into column density measurements for interstellar and intergalactic absorption lines (see Savage & Sembach 1991 for an extensive description of this technique). A potential disadvantage of the AOD method is that its characterization of the absorption arising in a given line is not unique; at different resolutions, instrumental broadening redistributes the intrinsic absorption profile differently with respect to radial velocity.

The PF approach simulates measured absorption line spectra by fitting instrumentally blurred multicomponent line profiles to the observed line profiles (Savage & Sembach 1991). This approach provides a better column density estimate of partially blended components and of those lines having evident departures from the linear part of the COG (Lopez et al. 2002). Lines

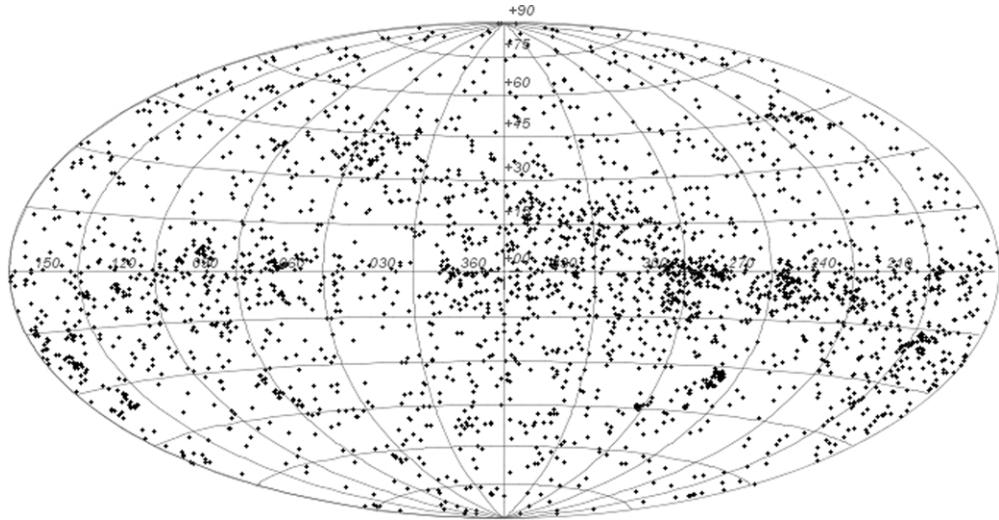


Figure 1. Distribution of observed stars plotted in an Aitoff plot with the Galactic center at the origin.

Table 1
Observed Interstellar Parameters

S. No. (1)	Star Name (2)	$E(B - V)$ (9)	Ref. (10)	$N(\text{Ca II}) \text{ cm}^{-2}$ (61)	Ref. (64)	$N(\text{H I}) \text{ cm}^{-2}$ (129)	Ref. (132)
1	AM Her	-999	-999	-999	-999	7.4000E+19	13, 228
2	AzV 018	0.200	34	1.0965E+13	34	9.0100E+21	31
3	AzV 018	0.174	31	8.5114E+12	34, 649	1.0965E+22	34
4	AzV 026	0.150	34	6.7608E+12	34	5.0119E+21	34
5	AzV 026	-999	-999	-999	-999	-999	-999
6	AzV 047	0.130	34	5.0119E+12	34	1.9953E+21	34
7	AzV 047	-999	-999	-999	-999	-999	-999
8	AzV 070	-999	-999	-999	-999	-999	-999
9	AzV 080	0.190	34	6.6069E+12	34	6.4565E+21	34
10	AzV 095	0.140	34	5.1286E+12	34	3.0903E+21	34
11	AzV 095	-999	-999	-999	-999	-999	-999
12	AzV 120	0.090	34	4.8978E+12	34	-999	-999
13	AzV 207	0.120	34	5.8884E+12	34	2.6915E+21	34
14	AzV 207	-999	-999	-999	-999	-999	-999
15	AzV 214	-999	-999	7.2444E+12	34, 649	2.5119E+21	34, 647
16	AzV 242	-999	-999	5.4954E+12	3, 649	1.9953E+21	34
17	AzV 321	0.120	34	2.8840E+12	34	-999	-999
18	AzV 321	-999	-999	-999	-999	-999	-999
19	AzV 332	-999	-999	-999	-999	-999	-999
20	AzV 332	-999	-999	-999	-999	-999	-999

Note. “-999” indicates values that are not available.

(This table is available in its entirety in a machine-readable form in the online journal. A portion is shown here for guidance regarding its form and content.)

of sight with multiple components are often more reliably analyzed with a fitting technique than with the COG because fitting a multiple-component COG requires a prior knowledge of radial velocity and Doppler spread parameter for each component, as well as their expected relative ratios. For the same reason, adjacent blended lines are also more reliably modeled using PF (Sonneborn et al. 2002).

The continuum reconstruction method derives a column density by multiplying the observed line intensity by the exponential of the optical depth. This produces a reconstructed profile that will be equal to the intrinsic continuum intensity for the true observed absorption optical depth (Spitzer 1978; Savage & Sembach 1991; Sofia et al. 1994).

Fruscione et al. (1994) have discussed the different methods of obtaining H I column densities from absorption line data and

the associated difficulties. The most direct means of obtaining H I column densities is through observations of the Lyman lines of hydrogen, the transitions to the ground state, but these are all in the UV and require space-based observations. Most such observations have come from observations of the Ly α line using data from *IUE* (van Steenberg & Shull 1988), where the lines are always heavily saturated and the H I column densities are determined from the damping wings. Absorption lines from other species provide a valuable alternative source for H I column densities ($N(\text{H I})$) can be estimated from an average ISM depletion and the observed column densities of the ionization species), but their interpretation is complicated by uncertain abundance ratios and multiple components in the line of sight.

As mentioned before, the primary focus of this work is to make the data available to the astronomical community;

Table 2
Observed Interstellar Parameters from Last Published Values

S. No. (1)	Star Name (2)	$E(B - V)$ (9)	Ref. (10)	$N(\text{Ca II}) \text{ cm}^{-2}$ (61)	Ref. (64)	$N(\text{H I}) \text{ cm}^{-2}$ (129)	Ref. (132)
1	AM Her	-999	-999	-999	-999	7.4000E+19	228
2	AzV 018	0.200	34	1.0965E+13	34	1.0965E+22	34
3	AzV 026	0.150	34	6.7608E+12	34	5.0119E+21	34
4	AzV 047	0.130	34	5.0119E+12	34	1.9953E+21	34
5	AzV 070	-999	-999	-999	-999	-999	-999
6	AzV 080	0.190	34	6.6069E+12	34	6.4565E+21	34
7	AzV 095	0.140	34	5.1286E+12	34	3.0903E+21	34
8	AzV 120	0.090	34	4.8978E+12	34	-999	-999
9	AzV 207	0.120	34	5.8884E+12	34	2.6915E+21	34
10	AzV 214	-999	-999	7.2444E+12	649	2.5119E+21	647
11	AzV 242	-999	-999	5.4954E+12	649	1.9953E+21	34
12	AzV 321	0.120	34	2.8840E+12	34	-999	-999
13	AzV 332	-999	-999	-999	-999	-999	-999
14	AzV 388	0.110	34	2.1380E+12	34	1.4125E+21	34
15	AzV 398	-999	-999	1.4454E+13	649	7.9433E+21	647
16	AzV 440	1.300	34	3.8905E+12	34	2.2909E+21	34
17	AzV 456	0.360	34	2.6915E+12	34	8.9125E+20	34
18	AzV 462	0.007	31	-999	-999	6.0000E+20	31
19	AzV 476	0.230	34	7.0795E+12	34	7.0795E+21	34
20	AzV 479	0.130	34	4.8978E+12	34	2.5119E+21	34

Note. “-999” indicates values that are not available.

(This table is available in its entirety in a machine-readable form in the online journal. A portion is shown here for guidance regarding its form and content.)

Table 3
References for the Data in Tables 1 and 2

No.	Reference
1	Welsh & Lallemand 2008
2	Bowen et al. 2008
3	Dixon & Sankrit 2008
4	Dixon et al. 2006
5	Otte & Dixon 2006
6	Savage & Lehner 2006
7	Welsh & Lallemand 2005
8	Welsh et al. 2005
9	Larson & Whittet 2005
10	Oegerle et al. 2005
11	Rachford et al. 2002
12	Clayton et al. 2000
13	Linsky et al. 2000
14	Vallerga 1996
15	Redfield & Linsky 2004
16	Redfield & Linsky 2001
17	Wolff et al. 1999
18	Gnaciński & Krogulec 2006
19	Cartledge et al. 2004
20	Cha et al. 2000

(This table is available in its entirety in a machine-readable form in the online journal. A portion is shown here for guidance regarding its form and content.)

however, in the paragraphs below, we will discuss some preliminary results from our analysis.

We find a tight relation between $E(B - V)$ and $N(\text{H I}) (=N(\text{H I}) + 2N(\text{H}_2))$ with a slope of $(6.1 \pm 0.2) \times 10^{21} \text{ atoms cm}^{-2} \text{ mag}^{-1}$ (Figure 2). This is close to the slope of $5.8 \times 10^{21} \text{ atoms cm}^{-2} \text{ mag}^{-1}$ found in the classic work of Bohlin et al. (1978) but with almost five times as many lines of sight. Four stars in our sample fall far away from this mean relation-

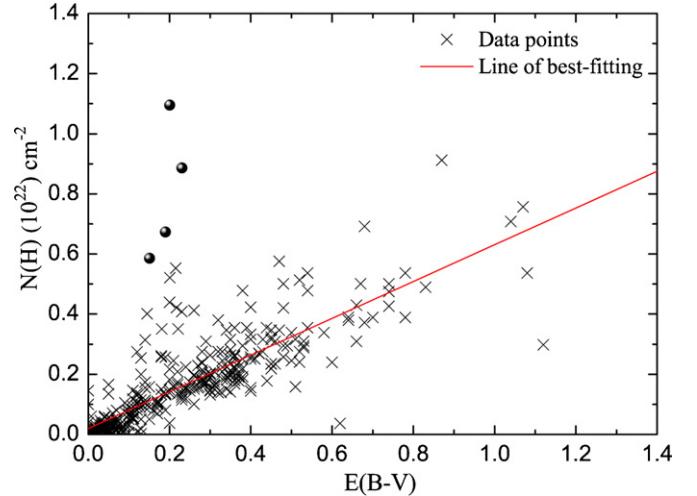


Figure 2. $N(\text{H})$ as a function of $E(B - V)$. The best-fit line has a slope of $(6.1 \pm 0.2) \times 10^{21} \text{ atoms cm}^{-2} \text{ mag}^{-1}$.

(A color version of this figure is available in the online journal.)

ship (filled circles in Figure 2). These four stars (AzV 18, AzV 26, AzV 80, and AzV 476) are in the Small Magellanic Cloud, which has a low metallicity and hence a high gas-to-dust ratio (Lequeux et al. 1984; Cartledge et al. 2005).

We have observations of many other species of different ionization states and their column density correlations with $E(B - V)$ and $N(\text{H I})$ along with their correlation coefficients tabulated in Tables 4 and 5, respectively. For instance, we find a fairly good correlation between singly ionized magnesium and neutral hydrogen with a slope of $N(\text{Mg II})/N(\text{H I})$ being $(7.6 \pm 0.3) \times 10^{-6}$ (Figure 3). On the other hand, neutral magnesium is found to be correlated very poorly with H I. The ionization energy of magnesium is low enough (7.5 eV) that most of the

Table 4
Summary of the Correlations Obtained with $E(B - V)$

S. No.	No. of Sight Lines	Correlations (atoms cm $^{-2}$)	Error in Slope	Correlation Coefficient, R
1	55	$N(\text{Kr I}) = 3.46 \times 10^{10} + 7.67 \times 10^{12} E(B - V)$	0.66×10^{12}	0.85
2	207	$N(\text{CH}) = -8.19 \times 10^{12} + 6.67 \times 10^{13} E(B - V)$	0.29×10^{13}	0.85
3	374	$N(\text{H}) = 1.87 \times 10^{20} + 6.12 \times 10^{21} E(B - V)$	0.20×10^{21}	0.84
4	82	$N(\text{Cl I}) = -4.04 \times 10^{20} + 2.50 \times 10^{14} E(B - V)$	0.19×10^{14}	0.83
5	139	$N(\text{O I}) = 2.29 \times 10^{16} + 2.45 \times 10^{18} E(B - V)$	0.15×10^{18}	0.81
6	396	$N(\text{H}_2) = -9.08 \times 10^{19} + 1.19 \times 10^{21} E(B - V)$	0.04×10^{21}	0.81
7	66	$N(\text{Ge II}) = 5.94 \times 10^{11} + 4.47 \times 10^{12} E(B - V)$	0.46×10^{12}	0.77
8	42	$N(\text{Cu II}) = 6.23 \times 10^{11} + 6.95 \times 10^{12} E(B - V)$	0.93×10^{12}	0.76
9	94	$N(\text{Ni}) = -1.97 \times 10^{16} + 4.33 \times 10^{17} E(B - V)$	0.41×10^{17}	0.74
10	186	$N(\text{K I}) = 2.65 \times 10^{11} + 1.60 \times 10^{12} E(B - V)$	0.11×10^{12}	0.73
11	72	$N(\text{C}_2) = 4.15 \times 10^{12} + 5.63 \times 10^{13} E(B - V)$	0.65×10^{13}	0.72
12	326	$N(\text{Mn II}) = 7.22 \times 10^{12} + 8.31 \times 10^{13} E(B - V)$	0.48×10^{13}	0.69
13	173	$N(\text{CH}+) = 1.33 \times 10^{12} + 3.16 \times 10^{13} E(B - V)$	0.26×10^{13}	0.68
14	40	$N(\text{HD}) = -1.99 \times 10^{15} + 1.02 \times 10^{16} E(B - V)$	0.20×10^{16}	0.64
15	125	$N(\text{P II}) = 2.48 \times 10^{13} + 4.85 \times 10^{14} E(B - V)$	0.54×10^{14}	0.63
16	444	$N(\text{Ca II}) = 6.88 \times 10^{11} + 8.04 \times 10^{12} E(B - V)$	0.49×10^{12}	0.62
17	48	$N(\text{Mg I}) = 8.02 \times 10^{11} + 1.07 \times 10^{14} E(B - V)$	0.21×10^{14}	0.60
18	130	$N(\text{CN}) = -3.93 \times 10^{12} + 1.95 \times 10^{13} E(B - V)$	0.23×10^{13}	0.60
19	806	$N(\text{H I}) = 5.12 \times 10^{20} + 3.05 \times 10^{21} E(B - V)$	0.15×10^{21}	0.57
20	203	$N(\text{Mg II}) = 3.67 \times 10^{15} + 2.26 \times 10^{16} E(B - V)$	0.25×10^{16}	0.54

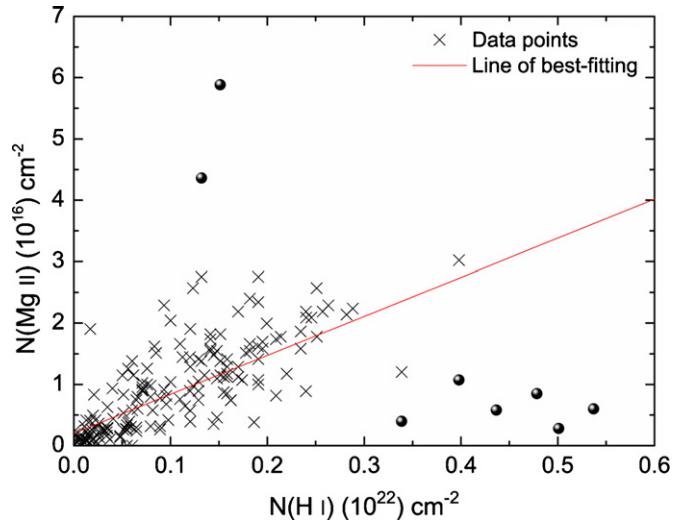


Figure 3. $N(\text{Mg II})$ as a function of $N(\text{H I})$. The best-fit line has a slope of $(7.6 \pm 0.3) \times 10^{-6}$ atoms cm $^{-2}$ mag $^{-1}$. The stars HD 175360, HD 149038, and HD 209975 deviate from the correlation. The deviation for HD 175360 is probably due to contamination of the interstellar features by stellar lines (Cartledge et al. 2004), and the two sight lines (HD 149038 and HD 209975) have potential saturation problems (Jenkins et al. 1986). Noted outliers also include HD 37021 and HD 37061, which are in Orion, HD 147933 from the Scorpis-Ophiuchus region, and HD 63005 and HD 36841.

(A color version of this figure is available in the online journal.)

interstellar magnesium is in its ionized state and this is reflected in their respective abundances.

The column density of neutral oxygen shows a good correlation with $N(\text{H I})$ (Figure 4), whereas O VI, which arises in a much hotter phase of the ISM, shows more scatter with $N(\text{H I})$ (Figure 5). Regions that contain collisionally ionized gas at temperatures above 10^5 K, and thus show O VI, are unrelated to the cooler neutral gas that holds the H I. The fact that the two show some correlation is probably due entirely to the fact that with stars at larger distances, both species independently have their column densities increase.

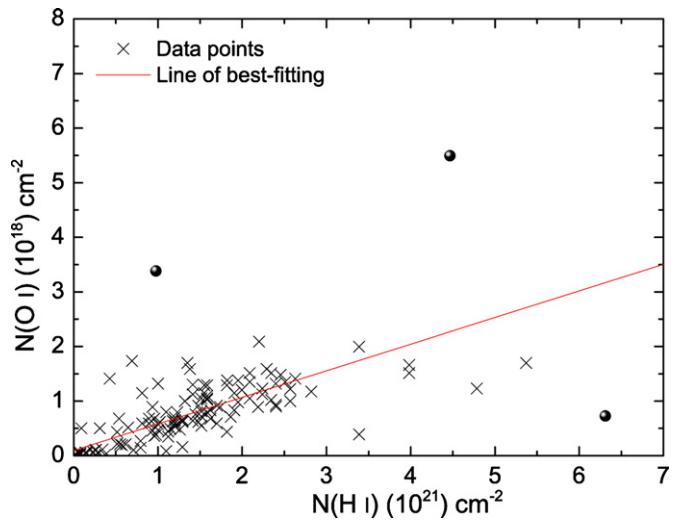


Figure 4. $N(\text{O I})$ as a function of $N(\text{H I})$. The best-fit line has a slope of $(4.5 \pm 0.2) \times 10^{-4}$ atoms cm $^{-2}$ mag $^{-1}$. The deviation for HD 148594 is probably due to contamination of the interstellar features by stellar lines (Cartledge et al. 2004). The two sight lines HD 42087 and HD 168076 have a great deal of uncertainty in the equivalent widths used in the COG for O I (Jensen et al. 2005).

(A color version of this figure is available in the online journal.)

3. CONCLUSIONS

We have collated absorption lines from a number of different published sources in order to create a unified database of interstellar column densities. These data are interesting in their own right, and we plan to use them to explore the three-dimensional morphology of the ISM, but they will also be invaluable in correcting for the effects of interstellar absorption in other observations. We plan to continue updating the data, as well as building a tool for ready access to the data and to column density predictions in different directions. We are also working on developing and testing models of the ISM using these and other data.

Table 5
Summary of the Correlations Obtained with $N(\text{H I})$

S. No.	No. of Sight Lines	Correlations (atoms cm^{-2})	Error in Slope	Correlation Coefficient, R
1	56	$N(\text{C II}) = -3.13 \times 10^{15} + 2.69 \times 10^{-4} N(\text{H I})$	0.06×10^{-4}	0.99
2	61	$N(\text{D I}) = 1.67 \times 10^{14} + 8.84 \times 10^{-6} N(\text{H I})$	0.24×10^{-6}	0.98
3	221	$N(\text{Mg II}) = 1.15 \times 10^{15} + 7.58 \times 10^{-6} N(\text{H I})$	0.34×10^{-6}	0.83
4	36	$N(\text{Cu II}) = 9.61 \times 10^{11} + 1.03 \times 10^{-9} N(\text{H I})$	0.12×10^{-4}	0.83
5	159	$N(\text{O I}) = 1.14 \times 10^{17} + 4.48 \times 10^{-4} N(\text{H I})$	0.24×10^{-4}	0.83
6	52	$N(\text{Kr I}) = 6.43 \times 10^{11} + 1.06 \times 10^{-9} N(\text{H I})$	0.10×10^{-9}	0.82
7	123	$N(\text{P II}) = 6.77 \times 10^{12} + 1.34 \times 10^{-7} N(\text{H I})$	0.09×10^{-7}	0.79
8	104	$N(\text{N I}) = -3.75 \times 10^{14} + 9.34 \times 10^{-5} N(\text{H I})$	0.73×10^{-5}	0.78
9	58	$N(\text{Ge II}) = 7.66 \times 10^{11} + 7.59 \times 10^{-10} N(\text{H I})$	0.93×10^{-10}	0.74
10	77	$N(\text{Cl I}) = -1.68 \times 10^{12} + 4.86 \times 10^{-8} N(\text{H I})$	0.54×10^{-8}	0.72
11	417	$N(\text{Ca II}) = 7.06 \times 10^{11} + 1.28 \times 10^{-9} N(\text{H I})$	0.07×10^{-9}	0.67
12	329	$N(\text{Ti II}) = 4.65 \times 10^{11} + 8.88 \times 10^{-10} N(\text{H I})$	0.54×10^{-10}	0.67
13	319	$N(\text{Mn II}) = 6.56 \times 10^{12} + 1.65 \times 10^{-8} N(\text{H I})$	0.11×10^{-8}	0.66
14	129	$N(\text{CH+}) = 7.80 \times 10^{11} + 7.10 \times 10^{-9} N(\text{H I})$	0.79×10^{-9}	0.62
15	84	$N(\text{Cl II}) = 1.25 \times 10^{13} + 7.37 \times 10^{-8} N(\text{H I})$	1.10×10^{-8}	0.60
16	192	$N(\text{O VI}) = 3.1 \times 10^{13} + 7.82 \times 10^{-8} N(\text{H I})$	0.84×10^{-8}	0.56
17	115	$N(\text{Al III}) = 2.76 \times 10^{12} + 1.27 \times 10^{-8} N(\text{H I})$	0.18×10^{-8}	0.55
18	392	$N(\text{Fe II}) = 2.62 \times 10^{14} + 4.51 \times 10^{-7} N(\text{H I})$	0.39×10^{-7}	0.51

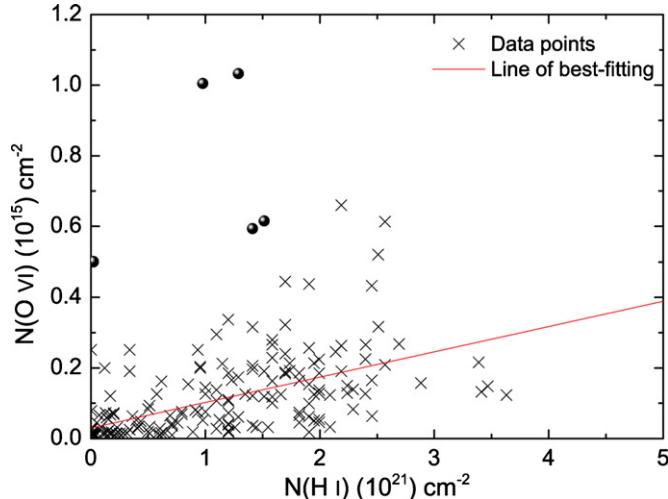


Figure 5. $N(\text{O VI})$ as a function of $N(\text{H I})$. The best-fit line has a slope of $(7.8 \pm 0.8) \times 10^{-8}$ atoms cm^{-2} mag $^{-1}$.

(A color version of this figure is available in the online journal.)

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APPENDIX

Data on all observed column densities are listed in Table 1 with a subset in Table 2 consisting of only the last published value for each line of sight. For example, for HD 35149, there are five different values for column density of neutral hydrogen, $N(\text{H I})$, which range from 3.63×10^{20} to $1.38 \times 10^{21} \text{ cm}^{-2}$. Of these five values, the one from the most recent publication has been entered in Table 2. We summed over multiple components to derive a total column density, if necessary. In the case of an extragalactic object, the sum extends over both the Milky Way

and the extragalactic components. The complete reference list is tabulated in Table 3. All three tables are published in full in the online version.

All data were taken directly from the published work except for the sky coordinates, spectral type, B , V , and K , which were taken from the SIMBAD database, if not referenced in the original work. Stellar distances were taken from *Hipparcos* (Van Leeuwene 2007) for those stars closer than 300 pc, otherwise from the published works. Both tables have been sorted by HD number, primarily, but with other subgroups when not available. The details of the columns in the tables are as follows:

- Column 1: serial number
- Column 2: star name
- Column 2a: SIMBAD identifier (only in Table 2)
- Column 3: Galactic longitude (l) in degree
- Column 4: Galactic latitude (b) in degree
- Column 5: spectral type
- Column 6: blue magnitude (B)
- Column 7: visual magnitude (V)
- Column 8: K magnitude
- Column 8a: Reference for Sp/L, B , V , and K (only in Table 1). All values of Sp/L, B , V , and K in Table 2 were taken from SIMBAD.
- Column 9: color excess $E(B - V)$
- Column 9a: positive error in $E(B - V)$ (only in Table 1)
- Column 9b: negative error in $E(B - V)$ (only in Table 1)
- Column 10: reference for $E(B - V)$
- Column 11: color excess $E(K - V)$
- Column 11a: positive error in $E(K - V)$ (only in Table 1)
- Column 11b: negative error in $E(K - V)$ (only in Table 1)
- Column 12: reference for $E(K - V)$
- Column 13: distance (d) in kpc
- Column 14: positive error in d in kpc
- Column 15: negative error in d in kpc

Column 16: Reference for distance. In Table 2, all the distances less than 300 pc were taken from SIMBAD.
 Column 17: column density $N(\text{Al II})$ in cm^{-2}
 Column 18: positive error in $N(\text{Al II})$ in cm^{-2}
 Column 19: negative error in $N(\text{Al II})$ in cm^{-2}
 Column 20: reference for $N(\text{Al II})$
 Column 21: column density $N(\text{Al III})$ in cm^{-2}
 Column 22: positive error in $N(\text{Al III})$ in cm^{-2}
 Column 23: negative error in $N(\text{Al III})$ in cm^{-2}
 Column 24: reference for $N(\text{Al III})$
 Column 25: column density $N(\text{Ar I})$ in cm^{-2}
 Column 26: positive error in $N(\text{Ar I})$ in cm^{-2}
 Column 27: negative error in $N(\text{Ar I})$ in cm^{-2}
 Column 28: reference for $N(\text{Ar I})$
 Column 29: column density $N(\text{C I})$ in cm^{-2}
 Column 30: positive error in $N(\text{C I})$ in cm^{-2}
 Column 31: negative error in $N(\text{C I})$ in cm^{-2}
 Column 32: reference for $N(\text{C I})$
 Column 33: column density $N(\text{C I}^*)$ in cm^{-2}
 Column 34: positive error in $N(\text{C I}^*)$ in cm^{-2}
 Column 35: negative error in $N(\text{C I}^*)$ in cm^{-2}
 Column 36: reference for $N(\text{C I}^*)$
 Column 37: column density $N(\text{C II})$ in cm^{-2}
 Column 38: positive error in $N(\text{C II})$ in cm^{-2}
 Column 39: negative error in $N(\text{C II})$ in cm^{-2}
 Column 40: reference for $N(\text{C II})$ in cm^{-2}
 Column 41: column density $N(\text{C II}^*)$ in cm^{-2}
 Column 42: positive error in $N(\text{C II}^*)$ in cm^{-2}
 Column 43: negative error in $N(\text{C II}^*)$ in cm^{-2}
 Column 44: reference for $N(\text{C II}^*)$
 Column 45: column density $N(\text{C III})$ in cm^{-2}
 Column 46: positive error in $N(\text{C III})$ in cm^{-2}
 Column 47: negative error in $N(\text{C III})$ in cm^{-2}
 Column 48: reference for $N(\text{C III})$
 Column 49: column density $N(\text{C IV})$ in cm^{-2}
 Column 50: positive error in $N(\text{C IV})$ in cm^{-2}
 Column 51: negative error in $N(\text{C IV})$ in cm^{-2}
 Column 52: reference for $N(\text{C IV})$
 Column 53: column density $N(\text{C}_2)$ in cm^{-2}
 Column 54: positive error in $N(\text{C}_2)$ in cm^{-2}
 Column 55: negative error in $N(\text{C}_2)$ in cm^{-2}
 Column 56: reference for $N(\text{C}_2)$
 Column 57: column density $N(\text{Ca I})$ in cm^{-2}
 Column 58: positive error in $N(\text{Ca I})$ in cm^{-2}
 Column 59: negative error in $N(\text{Ca I})$ in cm^{-2}
 Column 60: reference for $N(\text{Ca I})$
 Column 61: column density $N(\text{Ca II})$ in cm^{-2}
 Column 62: positive error in $N(\text{Ca II})$ in cm^{-2}
 Column 63: negative error in $N(\text{Ca II})$ in cm^{-2}
 Column 64: reference for $N(\text{Ca II})$

Column 65: column density $N(\text{CH})$ in cm^{-2}
 Column 66: positive error in $N(\text{CH})$ in cm^{-2}
 Column 67: negative error in $N(\text{CH})$ in cm^{-2}
 Column 68: reference for $N(\text{CH})$
 Column 69: column density $N(\text{CH}^+)$ in cm^{-2}
 Column 70: positive error in $N(\text{CH}^+)$ in cm^{-2}
 Column 71: negative error in $N(\text{CH}^+)$ in cm^{-2}
 Column 72: reference for $N(\text{CH}^+)$
 Column 73: column density $N(\text{Cl I})$ in cm^{-2}
 Column 74: positive error in $N(\text{Cl I})$ in cm^{-2}
 Column 75: negative error in $N(\text{Cl I})$ in cm^{-2}
 Column 76: reference for $N(\text{Cl I})$
 Column 77: column density $N(\text{Cl II})$ in cm^{-2}
 Column 78: positive error in $N(\text{Cl II})$ in cm^{-2}
 Column 79: negative error in $N(\text{Cl II})$ in cm^{-2}
 Column 80: reference for $N(\text{Cl II})$
 Column 81: column density $N(\text{CN})$ in cm^{-2}
 Column 82: positive error in $N(\text{CN})$ in cm^{-2}
 Column 83: negative error in $N(\text{CN})$ in cm^{-2}
 Column 84: reference for $N(\text{CN})$
 Column 85: column density $N(\text{CO})$ in cm^{-2}
 Column 86: positive error in $N(\text{CO})$ in cm^{-2}
 Column 87: negative error in $N(\text{CO})$ in cm^{-2}
 Column 88: reference for $N(\text{CO})$
 Column 89: column density $N(^{12}\text{CO})$ in cm^{-2}
 Column 90: positive error in $N(^{12}\text{CO})$ in cm^{-2}
 Column 91: negative error in $N(^{12}\text{CO})$ in cm^{-2}
 Column 92: reference for $N(^{12}\text{CO})$
 Column 93: column density $N(^{13}\text{CO})$ in cm^{-2}
 Column 94: positive error in $N(^{13}\text{CO})$ in cm^{-2}
 Column 95: negative error in $N(^{13}\text{CO})$ in cm^{-2}
 Column 96: reference for $N(^{13}\text{CO})$
 Column 97: column density $N(\text{Cr II})$ in cm^{-2}
 Column 98: positive error in $N(\text{Cr II})$ in cm^{-2}
 Column 99: negative error in $N(\text{Cr II})$ in cm^{-2}
 Column 100: reference for $N(\text{Cr II})$
 Column 101: column density $N(\text{Cu II})$ in cm^{-2}
 Column 102: positive error in $N(\text{Cu II})$ in cm^{-2}
 Column 103: negative error in $N(\text{Cu II})$ in cm^{-2}
 Column 104: reference for $N(\text{Cu II})$
 Column 105: column density $N(\text{D I})$ in cm^{-2}
 Column 106: positive error in $N(\text{D I})$ in cm^{-2}
 Column 107: negative error in $N(\text{D I})$ in cm^{-2}
 Column 108: reference for $N(\text{D I})$
 Column 109: column density $N(\text{F I})$ in cm^{-2}
 Column 110: positive error in $N(\text{F I})$ in cm^{-2}
 Column 111: negative error in $N(\text{F I})$ in cm^{-2}
 Column 112: reference for $N(\text{F I})$
 Column 113: column density $N(\text{Fe II})$ in cm^{-2}
 Column 114: positive error in $N(\text{Fe II})$ in cm^{-2}

- Column 115: negative error in $N(\text{Fe II})$ in cm^{-2}
 Column 116: reference for $N(\text{Fe II})$
 Column 117: column density $N(\text{Fe III})$ in cm^{-2}
 Column 118: positive error in $N(\text{Fe III})$ in cm^{-2}
 Column 119: negative error in $N(\text{Fe III})$ in cm^{-2}
 Column 120: reference for $N(\text{Fe III})$
 Column 121: column density $N(\text{Ge II})$ in cm^{-2}
 Column 122: positive error in $N(\text{Ge II})$ in cm^{-2}
 Column 123: negative error in $N(\text{Ge II})$ in cm^{-2}
 Column 124: reference for $N(\text{Ge II})$
 Column 125: column density $N(\text{H})$ in cm^{-2}
 Column 126: positive error in $N(\text{H})$ in cm^{-2}
 Column 127: negative error in $N(\text{H})$ in cm^{-2}
 Column 128: reference for $N(\text{H})$
 Column 129: column density $N(\text{H I})$ in cm^{-2}
 Column 130: positive error in $N(\text{H I})$ in cm^{-2}
 Column 131: negative error in $N(\text{H I})$ in cm^{-2}
 Column 132: reference for $N(\text{H I})$
 Column 133: column density $N(\text{H}_2)$ in cm^{-2}
 Column 134: positive error in $N(\text{H}_2)$ in cm^{-2}
 Column 135: negative error in $N(\text{H}_2)$ in cm^{-2}
 Column 136: reference for $N(\text{H}_2)$
 Column 137: column density $N(\text{HD})$ in cm^{-2}
 Column 138: positive error in $N(\text{HD})$ in cm^{-2}
 Column 139: negative error in $N(\text{HD})$ in cm^{-2}
 Column 140: reference for $N(\text{HD})$
 Column 141: column density $N(\text{He I})$ in cm^{-2}
 Column 142: positive error in $N(\text{He I})$ in cm^{-2}
 Column 143: negative error in $N(\text{He I})$ in cm^{-2}
 Column 144: reference for $N(\text{He I})$
 Column 145: column density $N(\text{He II})$ in cm^{-2}
 Column 146: positive error in $N(\text{He II})$ in cm^{-2}
 Column 147: negative error in $N(\text{He II})$ in cm^{-2}
 Column 148: reference for $N(\text{He II})$
 Column 149: column density $N(\text{K I})$ in cm^{-2}
 Column 150: positive error in $N(\text{K I})$ in cm^{-2}
 Column 151: negative error in $N(\text{K I})$ in cm^{-2}
 Column 152: reference for $N(\text{K I})$
 Column 153: column density $N(\text{Kr I})$ in cm^{-2}
 Column 154: positive error in $N(\text{Kr I})$ in cm^{-2}
 Column 155: negative error in $N(\text{Kr I})$ in cm^{-2}
 Column 156: reference for $N(\text{Kr I})$
 Column 157: column density $N(\text{Mg I})$ in cm^{-2}
 Column 158: positive error in $N(\text{Mg I})$ in cm^{-2}
 Column 159: negative error in $N(\text{Mg I})$ in cm^{-2}
 Column 160: reference for $N(\text{Mg I})$
 Column 161: column density $N(\text{Mg II})$ in cm^{-2}
 Column 162: positive error in $N(\text{Mg II})$ in cm^{-2}
 Column 163: negative error in $N(\text{Mg II})$ in cm^{-2}
 Column 164: reference for $N(\text{Mg II})$
 Column 165: column density $N(\text{Mn II})$ in cm^{-2}
 Column 166: positive error in $N(\text{Mn II})$ in cm^{-2}
 Column 167: negative error in $N(\text{Mn II})$ in cm^{-2}
 Column 168: reference for $N(\text{Mn II})$
 Column 169: column density $N(\text{N I})$ in cm^{-2}
 Column 170: positive error in $N(\text{N I})$ in cm^{-2}
 Column 171: negative error in $N(\text{N I})$ in cm^{-2}
 Column 172: reference for $N(\text{N I})$
 Column 173: column density $N(\text{N II})$ in cm^{-2}
 Column 174: positive error in $N(\text{N II})$ in cm^{-2}
 Column 175: negative error in $N(\text{N II})$ in cm^{-2}
 Column 176: reference for $N(\text{N II})$
 Column 177: column density $N(\text{Na I})$ in cm^{-2}
 Column 178: positive error in $N(\text{Na I})$ in cm^{-2}
 Column 179: negative error in $N(\text{Na I})$ in cm^{-2}
 Column 180: reference for $N(\text{Na I})$
 Column 181: column density $N(\text{Ni II})$ in cm^{-2}
 Column 182: positive error in $N(\text{Ni II})$ in cm^{-2}
 Column 183: negative error in $N(\text{Ni II})$ in cm^{-2}
 Column 184: reference for $N(\text{Ni II})$
 Column 185: column density $N(\text{O I})$ in cm^{-2}
 Column 186: positive error in $N(\text{O I})$ in cm^{-2}
 Column 187: negative error in $N(\text{O I})$ in cm^{-2}
 Column 188: reference for $N(\text{O I})$
 Column 189: column density $N(\text{O VI})$ in cm^{-2}
 Column 190: positive error in $N(\text{O VI})$ in cm^{-2}
 Column 191: negative error in $N(\text{O VI})$ in cm^{-2}
 Column 192: reference for $N(\text{O VI})$
 Column 193: column density $N(\text{P II})$ in cm^{-2}
 Column 194: positive error in $N(\text{P II})$ in cm^{-2}
 Column 195: negative error in $N(\text{P II})$ in cm^{-2}
 Column 196: reference for $N(\text{P II})$
 Column 197: column density $N(\text{S I})$ in cm^{-2}
 Column 198: positive error in $N(\text{S I})$ in cm^{-2}
 Column 199: negative error in $N(\text{S I})$ in cm^{-2}
 Column 200: reference for $N(\text{S I})$
 Column 201: column density $N(\text{S II})$ in cm^{-2}
 Column 202: positive error in $N(\text{S II})$ in cm^{-2}
 Column 203: negative error in $N(\text{S II})$ in cm^{-2}
 Column 204: reference for $N(\text{S II})$
 Column 205: column density $N(\text{Si II})$ in cm^{-2}
 Column 206: positive error in $N(\text{Si II})$ in cm^{-2}
 Column 207: negative error in $N(\text{Si II})$ in cm^{-2}
 Column 208: reference for $N(\text{Si II})$
 Column 209: column density $N(\text{Si IV})$ in cm^{-2}
 Column 210: positive error in $N(\text{Si IV})$ in cm^{-2}
 Column 211: negative error in $N(\text{Si IV})$ in cm^{-2}
 Column 212: reference for $N(\text{Si IV})$
 Column 213: column density $N(\text{Ti II})$ in cm^{-2}
 Column 214: positive error in $N(\text{Ti II})$ in cm^{-2}

- Column 215: negative error in $N(\text{Ti II})$ in cm^{-2}
 Column 216: reference for $N(\text{Ti II})$
 Column 217: column density $N(\text{Zn II})$ in cm^{-2}
 Column 218: positive error in $N(\text{Zn II})$ in cm^{-2}
 Column 219: negative error in $N(\text{Zn II})$ in cm^{-2}
 Column 220: reference for $N(\text{Zn II})$.

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