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# What is (are) the total D/H ratio(s) within 1 kpc of the Sun?

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**Abstract.** I present the latest compilation of D/H measurements by FUSE and previous satellites. The most likely explanation of the wide range in the gas phase $(\mathrm{D/H})_{gas}$ values beyond the Local Bubble is deuterium depletion on to dust grains, which is supported by both theory and the correlation of $(\mathrm{D/G})_{gas}$ with iron depletion. I propose that the best value for the $(\mathrm{D/H})_{total}$ ratio (gas and dust) within 1 kps of the Sun is $23.4 \pm 1.4$ ppm, which indicates that deuterium astration has been much smaller that recent models predict.

## 1. Measurements of D/H in the Interstellar Medium

FUSE observations have greatly increased the number of lines of sight with accurate gas phase $(\mathrm{D/H})_{gas}$ measurements. Figure 1 shows the results for 45 lines of sight, including 18 based on FUSE data, published by Wood et al. (2004) or presented at this meeting. Within the Local Bubble ($\log N_{HI} < 19.2$), $(\mathrm{D/H})_{gas}$ is homogeneous with a value of $15.6 \pm 0.4$ ppm, but beyond the Local Bubble measurements by all instruments indicate a factor of four range with an apparant clumping at $8.7 \pm 0.8$ ppm for lines of sight with $\log N_{HI} > 20.7$.

The wide range in measured $(\mathrm{D/H})_{gas}$ values is unlikely to be due to measurement errors, given the different instruments, authors, and analysis codes. Spatial variations in deuterium astration is also an unlikely explanation as the abundance of oxygen, the most abundant metal, does not vary within about 1 kpc of the Sun. Spatial variations in the infall of near-primordial gas from the IGM is a possible explanation that should be explored. I believe that the most likely explanation is depletion of deuterium on to dust grains in cool, undisturbed regions of the ISM and the return of deuterium to the gas phase when strong shock waves or radiation from a nearby hot star evaporates the grains. The $\gamma^2$ Vel line of sight is likely a good example of the latter. For a discussion of the deuterium depletion hypothesis see Draine (2003; this volume).

A prediction of the deuterium depletion hypothesis is that the depletion of refractory elements should be correlated with $(\mathrm{D/H})_{gas}$. Figure 2 shows that $(\mathrm{D/H})_{gas}$ is indeed correlated with iron depletion. In particular, the $\gamma^2$ Vel line of sight shows high $(\mathrm{D/H})_{gas}$ and relatively small iron depletion. This work is described in detail by Linsky et al. (in preparation).

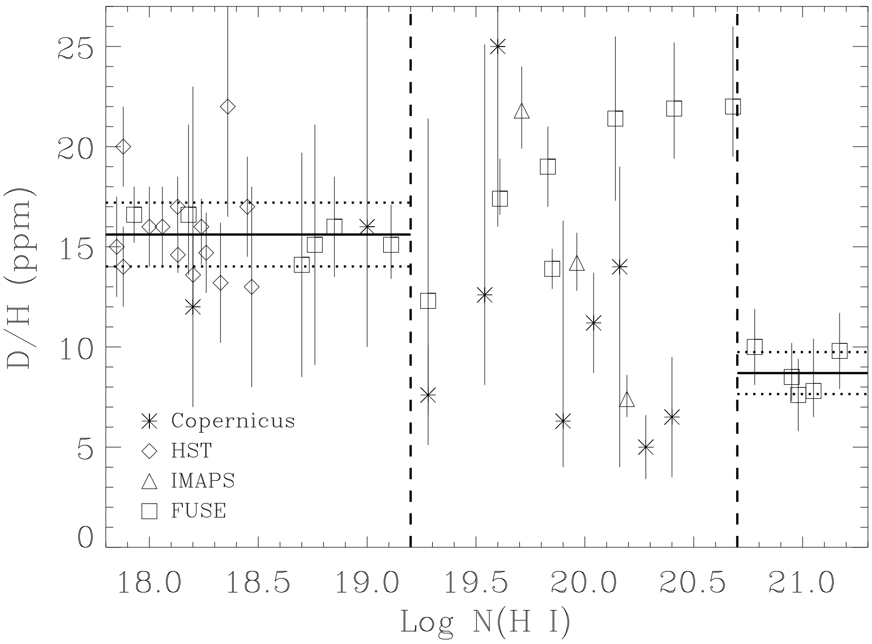


Figure 1. Gas phase $(D/H)_{gas}$ vs. hydrogen column density. The symbols indicate the observing instrument and the error bars are $\pm 1\sigma$. Horizontal lines indicate mean values and $\pm 1\sigma$ of $(D/H)_{gas}$ in each region of N(H I).

## 2. Conclusions

- The broad range of $(D/H)_{gas}$ measurements obtained from analysis of observations with FUSE and earlier instruments for lines of sight to targets located beyond the Local Bubble (log N(H I) > 19.2) show about a factor of 4 range that cannot be explained by measurement errors.

- The most likely explanation for the observed low values of $(D/H)_{gas}$ is deuterium depletion on to grains when the gas has been allowed to cool for a long time. High values of $(D/H)_{gas}$ likely occur for lines of sight that have been recently shocked or are located near a hot star.

- The best estimate of $(D/H)_{total}$ should therefore be the highest credible measured values of $(D/H)_{gas}$, since these lines of sight should have the least deuterium depletion. For the best estimate of $(D/H)_{total}$ within 1 kpc of the Sun, I take the mean value, $(D/H)_{gas} = 23.4 \pm 1.4$ ppm, for the four stars with the highest values of $(D/H)_{gas}$.

- The astration factor over the Galaxy lifetime is $f_D = (D/H)_{prim}/(D/H)_{total}$. For $(D/H)_{prim} = 25.0 \pm 3.2$ ppm obtained from analysis of the WMAP data (Spergel et al. 2003) or $27.8 \pm 4.1$ obtained from the analysis of quasar spectra (Kirkman et al. 2003), $f_D = 1.07 \pm 0.25$ or $1.19 \pm 0.3$, respectively.

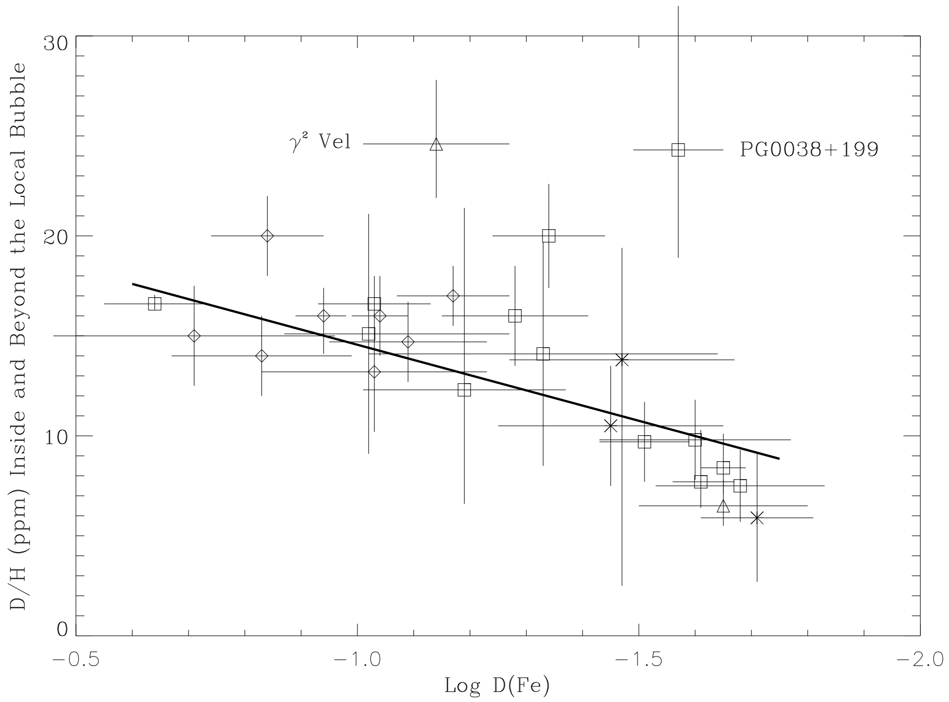


Figure 2. Gas phase D/H values towards stars inside the Local Bubble and outside (after subtracting the Local Bubble foreground) vs. depletion of iron. Symbols are the same as in Figure 1. The solid line is a least squares linear fit to the data weighted by the inverse errors.

- Both values of the astration factor are uncomfortably small compared with recent estimates of $f_D \sim 1.5$ obtained from Galactic chemical evolution models (Romano et al. 2003). The difference between our results for $(D/H)_{total}$ and the model predictions for Galactic astration to the age of the Sun indicates that the model assumptions should be examined and that more FUSE measurements are needed, especially for lines of sight with high values of $(D/H)_{gas}$.

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## References

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