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Spatial Variations in the Atomic D/H Ratio in the ISM

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Abstract. Observations with IMAPS demonstrate that interstellar atomic D/H abundance ratios differ by a factor of 3 on the sightlines toward δ Ori A, ζ Pup, and γ^2 Vel, early-type stars within $\sim$ 500 pc of the Sun. The observed D/H differences are not inversely correlated with N/H, as would be expected if injection of CNO-processed material was the primary mechanism for the D/H abundance variations in the ISM.

1. Introduction

Observations made with the Interstellar Medium Absorption Profile Spectrograph (IMAPS, see Jenkins et al. 1996) on the US-German ORFEUS-SPAS II mission in late 1996 provide the first new measurements of Galactic interstellar atomic deuterium beyond the local ISM ($d \lesssim 80$ pc) since the *Copernicus* mission in the 1970s. IMAPS is an objective grating echelle spectrograph designed for high spectral resolution ($\lambda/\Delta\lambda \sim 80,000$) in the far UV (930-1160Å). IMAPS observed δ Orionis A (O9.5 II), γ^2 Velorum (WC8+O8), and ζ Puppis (O4 Iaf). H I Lyδ (949.485Å) and Lyϵ (937.548Å). In this contribution we summarize results of Jenkins et al. (1999) for δ Ori A and by Sonneborn et al. (2000) for γ^2 Vel and ζ Pup.

2. D, H, and N Analyses

The total D I column density ($N_{\rm DI}$) toward each star was determined by simultaneously modelling multiple D I profiles (Lyδ 949.485Å and Lyϵ 937.548Å, plus Lyγ 972.272Å for ζ Pup). The parameters defining the profiles are $N_{\rm DI}$, temperature T, the continuum fit near the D I and H I features, and the background (zero intensity) level near each line. The velocity profile of neutral gas toward each star was defined by absorption features from several multiplets of N I recorded in the IMAPS spectra, covering a range of 1.80 in log(fλ). The N I velocity profiles ($N_a(v)$) were used as templates for modelling the D I profiles. Analysis of O I 1039, 1302, and 1356 confirms that N I accurately traces H I on these sightlines. This approach tightens the error limits for $N_{\rm DI}$. For each star, the optimum solution for $N_{\rm DI}$ was determined by minimizing χ^2 for the multi-parameter fit. The details of this analysis technique are given in Jenkins et al. (1999) and Sonneborn et al. (2000). $N_{\rm NI}$ was determined by integrating $N_a(v)$.

Values of the total H I column density ($N_{\rm HI}$) for these stars in the literature have sufficiently large uncertainties that new evaluations were made. $N_{\rm HI}$ was measured by performing a χ^2 analysis of Lyα using all the available *IUE* SWP high-dispersion spectra for each star. The large number of *IUE* spectra significantly reduces statistical errors in $N_{\rm HI}$ so that systematic errors (e.g. binary phase, stellar variability) could be assessed and incorporated into the error estimates. In this $N_{\rm HI}$ range ($\sim 10^{20}{\rm cm}^{-2}$), the same gas produces the broad H I Lyα wings and the D I Lyδ and Lyϵ features.

The D/H and N/H abundance ratios given in Table 1 (errors are 90% confidence limits, 1.65σ) conclusively demonstrate that D/H in the ISM can vary substantially from that measured in the local ISM (D/H $= 1.60 \pm 0.17 \times 10^{-5}$, Piskunov et al. 1997). We find a difference of 3X in D/H between δ Ori and γ^2 Vel. There is no trend of lower D/H with higher metallicity, as would be expected if the injection of CNO-processed (i.e. D-depleted) material into the ISM was the primary mechanism responsible for the D/H variability. (O/H is also low toward δ Ori A– Meyer et al. 1998) Measuring D, N, and O abundances on many sightlines in the Milky Way, understanding the distribution function for D/H ratios, and its correlation with Galactic and stellar environments are major objectives of the FUSE mission (Sonneborn et al., this volume).

Table 1. IMAPS Deuterium and Nitrogen Abundance Ratios

Star	$l^{\rm II}$	$b^{\rm II}$	d (pc)	N/H (10^{-5})	D/H (10^{-5})
δ Ori A	203°9	-17°7	372	3.97 ± 0.32	0.74 ± 0.16
ζ Pup	256°0	-4°7	429	8.30 ± 1.22	1.42 ± 0.24
γ^2 Vel	262°8	-7°7	258	7.99 ± 1.02	2.18 ± 0.33

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