OBSERVATIONS OF INTERSTELLAR HYDROGEN AND DEUTERIUM TOWARD ALPHA CENTAURI A

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ABSTRACT

We present a composite profile of the Lyα emission line of α Cen A, obtained from 10 individual spectra with the high-resolution spectrograph aboard the *International Ultraviolet Explorer (IUE)* satellite. There is excellent overall agreement with two previous *Copernicus* observations. Interstellar deuterium is detected, and a lower limit is set on the deuterium to hydrogen ratio of $n_{\mathrm{D\,I}}/n_{\mathrm{H\,I}} > 8 \times 10^{-6}$. In addition, the deuterium bulk velocity appears blueshifted by 8 ± 2 km s^{-1} with respect to interstellar hydrogen, suggesting a nonuniform medium along the line of sight.

Subject headings: interstellar: abundances — interstellar medium — stars: late-type — ultraviolet: spectra

I. INTRODUCTION

Interstellar hydrogen and deuterium can be observed as absorption features cutting into the chromospheric Lyα emission of nearby late-type stars. As a nearby solar twin, α Cen A (G2 V, $d = 1.34$ pc, $l^{\mathrm{II}} = 316°$, $b^{\mathrm{II}} = -1°$) provides the best opportunity for disentangling chromospheric and interstellar effects, both of which contribute to the formation of the observed Lyα profile. In addition, the short line of sight to α Cen allows one to probe at high spatial resolution the interior of the warm ($n_{\mathrm{H\,I}} \sim 0.1$ cm^{-3}, $T \sim 10^4$ K) interstellar cloud which envelops the Sun. We also note that α Cen is in the upwind direction of the interstellar wind entering the solar system as observed in the local standard of rest (Weller and Meier 1981).

The Lyα emission of α Cen A was first detected by Dupree, Baliunas, and Shipman (1977), using the *Copernicus* satellite. They reported a low value for the ratio of interstellar deuterium to hydrogen ($n_{\mathrm{D\,I}}/n_{\mathrm{H\,I}} = 2.4[+0.12, -0.07] \times 10^{-6}$), while, in the same paper, finding a high value toward another nearby star, Capella ($d = 13.2$ pc, $l^{\mathrm{II}} = 163°$, $b^{\mathrm{II}} = 5°$; $n_{\mathrm{D\,I}}/n_{\mathrm{H\,I}} = 3.9[+5.7, -1.7] \times 10^{-5}$). The existence of variations in $n_{\mathrm{D\,I}}/n_{\mathrm{H\,I}}$ over such short length scales might be difficult to explain, and would cast doubt on the usefulness of deuterium as a cosmological probe. However, McClintock *et al.* (1978) later analyzed the same *Copernicus* data, and arrived at quite different conclusions. They argued that the square-well–like hydrogen absorption profile in α Cen A indicates a velocity dispersion greater than the 8–10 km s^{-1} assumed by Dupree *et al.* They also pointed out that the narrow feature assumed to have been D I absorption is incompatible with both the instrumental resolution, and with the width of the interstellar H I absorption profile. Finally, McClintock *et al.* showed that a large range ($0.9 \times 10^{-5} < n_{\mathrm{D\,I}}/n_{\mathrm{H\,I}} < 2.4 \times 10^{-5}$) of $n_{\mathrm{D\,I}}/n_{\mathrm{H\,I}}$ values is consistent with the rather low signal-to-noise *Copernicus* data.

Because of the importance of this line of sight, and of the

controversy surrounding $n_{\mathrm{D\,I}}/n_{\mathrm{H\,I}}$, we have obtained a sequence of 10 high-resolution images of α Cen A with the *International Ultraviolet Explorer (IUE)* (Boggess *et al.* 1978). The poorer spectral resolution of the *IUE* data (~ 0.1 Å), compared with that of the *Copernicus* data (~ 0.05 Å), is offset by its much greater signal-to-noise ratio. We have also obtained data, from the *Copernicus* archives, of a previously unpublished 1978 observation of the Lyα line.

II. DATA REDUCTION

The dates and exposure times for the various observations are given in Tables 1 and 2. We now give details of the data reduction.

a) Copernicus 1976

We have made three minor modifications to the way the data were reduced by McClintock *et al.* (1978). The spacecraft orbital motion requires that individual scans be placed on a common wavelength mesh before they can be co-added (McClintock 1977). We have now selected a wavelength mesh that minimizes interpolation of the individual scans. Second, the method of data reduction which uses the U2 tube as a real-time monitor of particle backgrounds has been rejected in favor of use of the "standard table," because electronic pickup in the U2 tube (Gerola *et al.* 1977) causes spurious counts which systematically alter the background at the ~ 1 count level. Finally, the "standard table" of particle backgrounds was multiplied by a factor (0.82) to account for the decreased sensitivity of the U1 tube to particle backgrounds, since the

TABLE 1

Copernicus OBSERVATIONS

Days	Year	Number of Complete Scans	Calibration[a]
156–157	1976	27	0.337
141–152	1978	100	0.683

[a] Photons cm^{-2} Å^{-1} s^{-1} [counts (14 s)$^{-1}$]$^{-1}$.

TABLE 2

IUE OBSERVATIONS

Image Number	Date	Exposure Time (minutes)
Group 1:	Velocity Scale -56 km s^{-1}	
SWP 5541	1979 Jun 16	120
SWP 5542	1979 Jun 16	120
SWP 5543	1979 Jun 16	60
SWP 5546	1979 Jun 16	60
SWP 5547	1979 Jun 16	60
Group 2:	Velocity Scale 0 km s^{-1}	
SWP 5544	1979 Jun 16	60
SWP 5545	1979 Jun 16	60
Group 3:	Velocity Scale -37 km s^{-1}	
SWP 6477	1979 Sep 12	120 (44)[a]
Group 4:	Velocity Scale -48 km s^{-1}	
SWP 6478	1979 Sep 12	120 (58)[a]
SWP 6479	1979 Sep 12	102 (34)[a]

NOTE.—Spectra grouped together have a common velocity scale, measured in the stellar rest frame. The velocity scale depends on position of the star in the large aperture, as well as on the date of observation.

[a] Number in parentheses is an effective exposure time, derived by normalizing to SWP 5542.

creation of the standard table in 1973 (Walter Upson, personal communication). This decreased the rms errors and slightly altered the spectral shape, because the red and blue wings of the line were observed separately and have different average background rates.

b) *Copernicus 1978*

This observation is of about equal sensitivity to the first *Copernicus* observation. Although the detector efficiency had dropped by a factor of 2, there are 4 times as many scans per mesh point. We have deleted three scans which contain the most rapidly varying backgrounds, and an rms deviation from the summed spectra greater than 9 counts per mesh point. None of the remaining 209 scans show deviations greater than 7 counts per mesh point. We tested for systematic errors in the data by deleting scans with high backgrounds, scans interrupted after one standard routine, scans taken near the South Atlantic Anomaly, and scans from the end of the 11 day observing period. None of these steps caused any major changes in the line profile.

c) *IUE 1979*

We obtained seven high-dispersion, large ($10'' \times 20''$) aperture,[3] short-wavelength (SWP) images of α Cen A on 1979 June 16, and an additional three images on 1979 September 12. The 1979 June images (SWP 5541–5547) were reprocessed with the correct intensity transfer function (ITF) in 1980 April. On several exposures the star was moved toward one edge of the

major axis of the large aperture, in order to avoid contamination of the interstellar D I feature by the Lyα sky background. The photometric precision of the 1979 September observations (SWP 6477–6479) was compromised by the use of incorrect target coordinates, so that the stellar image was positioned off the edge of the aperture. An effective exposure time for these images (Table 2) was derived by normalizing to SWP 5542, which showed the best signal-to-noise properties.

The spectra were extracted with our own software from the geometrically and photometrically corrected image. Following Mallama *et al.* (1979), the spectral flux was determined by summing together five diagonal pixels within a "jagged" slit centered on the dispersion line. The jagged slit provides somewhat improved spectral resolution, by doubling the data sampling rate to that used in current *IUE* high-dispersion processing (Bohlin and Turnrose 1982). Use of our own software also enabled us to accurately register the extraction slit at Lyα, in the direction perpendicular to the dispersion.

The diffuse Lyα sky background is imaged by the large aperture onto the dispersion line, where it contaminates about 0.6 Å of the stellar spectrum. We have modeled the spectral dependence of the Lyα sky background using a spectrum of β Dra (SWP 5437), which is distant enough (200 pc) that its own Lyα emission is completely obliterated by interstellar absorption. We corrected our α Cen A spectra for diffuse Lyα emission, by subtracting enough of this sky-only spectrum to make the interstellar core go to zero flux (Fig. 1). This technique could not be used for the 1979 September α Cen A data because the stellar image (and the extraction slit) was skewed off the major axis of the large aperture. Instead, the contaminated data in these images were deleted from consideration.

It should also be noted that the sky background is due to scattering of solar Lyα by H I both in the interstellar wind entering the solar system, as well as in the Earth's geocorona. Depending on the time of the year and the view direction, the interstellar wind component may be shifted by as much as 40
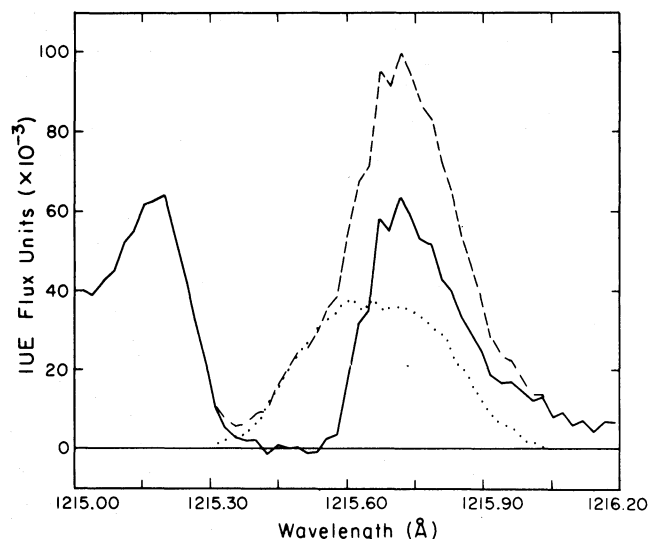
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[3] Use of the small (3″ circle) aperture would have been preferable, so as to eliminate much of the diffuse Lyα sky background. However, the acquisition of α Cen A requires a blind offset from the 22′ distant star SAO 252855, because the fine error sensor (FES), normally used for target acquisition, will seek the center of light of the binary system (Ayres and Linsky 1980). The pointing errors resulting from the blind offset precluded the use of the small aperture.

FIG. 1.—Our technique for removing the Lyα sky background contribution from our spectra of α Cen A is illustrated for image SWP 5541. A sky-only spectrum (*dotted line*) has been subtracted from the gross spectrum of α Cen A (*dashed line*). The sky-only spectrum has been scaled by a factor such that zero flux remains in the interstellar H I core (at 1215.45 Å) after the subtraction (*solid line*).

km s^{-1} from geocoronal Lyα, and be resolved spectroscopically in *IUE* large-aperture, high-dispersion images (Clarke 1983). However, from the direction and velocity of H I in the interstellar wind observed by Adams and Frisch (1977), we expect the interstellar wind component to be blueshifted from geocoronal Lyα by only 5 km s^{-1} both in our sky-only spectrum and in the 1979 June spectra of α Cen A.

Our method of subtracting the Lyα sky background is sensitive to shifts of the monochromatically illuminated large aperture on the spectral format. To minimize this effect, we used the algorithm of Thompson, Turnrose, and Bohlin (1982) to correct for thermal distortions of the spectral format. The correction for the echelle blaze, and the absolute calibration, were done as described in Ayres *et al.* (1982). A wavelength scale for each stellar spectrum was established using other chromospheric lines in the short-wavelength spectrum, and assuming a uniform velocity shift across the camera face.

The errors associated with an *IUE* line profile are difficult to quantify, because of uncertainties in the intensity transfer function, and because of the existence of fixed pattern noise in the camera. The Lyα line profile may be affected by the persistent spurious features seen in the SWP camera at high dispersion by York and Jura (1982), and at low dispersion by Hackney, Hackney, and Kondo (1982). Fixed pattern noise probably also limits the improvement in signal-to-noise after the co-addition of multiple spectra; both West and Shuttleworth (1981) and Gilra *et al.* (1982) find little improvement in signal-to-noise from the co-addition of more than 3–5 spectra. We have adopted the following approach to these problems. First, we conservatively estimated the errors in each individual line profile, based on the observed signal-to-noise properties of *IUE* spectra. We then co-added the 10 *IUE* spectra, assuming a reduction in errors only when differing wavelength scales made fixed pattern noise become uncorrelated. The wavelength scales may differ either because of a shift in the placement of the star in the large aperture, or because of the change in the Earth's velocity between the June and September observations.

A baseline uncertainty for each spectrum was derived using the rms fluctuations in a flux-free region near 1218 Å. We then accounted for photon noise by adding an error term based on a signal-to-noise of 17:1. We derived this approximation from the typical signal-to-noise of 25:1 found by York and Jura (1982) in spectra obtained from short exposures where photon noise is expected to predominate. Our signal-to-noise is reduced by a factor of 1.6 since we have doubled the data sampling rate (Bohlin and Turnrose 1982). We then considered three sources of error associated with the subtraction of the Lyα sky background: the background fluctuations in the sky-only spectrum; the uncertainty in setting an interstellar core of zero flux; and, finally, the possibility of wavelength shifts of up to 5 km s^{-1}.

As indicated in Table, 2, each of the 10 spectra of α Cen A were placed into one of four groups, according to the observed velocity shift of their chromospheric emission lines. Spectra within each group were then averaged together, without assuming any improvement in signal-to-noise. The resulting four spectra were then placed on a common wavelength scale and co-added, now assuming uncorrelated errors. Note that the velocity separation of independent data points in our spectral extraction procedure is 5.5 km s^{-1}.

There are two pieces of evidence that our somewhat crude error analysis has not significantly underestimated the true uncertainties. First, the rms variations between the four groups

of spectra agree well with that expected from our error analysis of the individual line profiles. In addition, we obtain good model fits to the final *IUE* spectrum, with lower reduced χ^2 values than for either of the *Copernicus* spectra (see Fig. 5).

III. ANALYSIS METHODS

Our analysis of the data follows the procedure of Anderson *et al.* (1978). Briefly, we construct theoretical spectra based on an intrinsic solar-type stellar emission and a uniform, thermally broadened interstellar medium. The 10 parameters in the model are adjusted to minimize the χ^2 goodness of fit. The interstellar parameters are the bulk velocity and densities of H I and D I, and the velocity dispersion b_{HI}. We model the intrinsic line self-reversal as a two-parameter Gaussian, instead of the three-parameter trapezoid used by Anderson *et al.* The depth of the self-reversal is allowed to vary from 0.3 to 0.95 of the peak height.

To compare with the *IUE* data, the theoretical spectra are convolved with a 0.1 Å Gaussian instrumental profile. We have applied similar data reduction and analysis techniques to an *IUE* Lyα profile of Procyon (SWP 6660) and obtained interstellar parameters consistent with those previously obtained with *Copernicus* (Landsman *et al.* 1984).

IV. RESULTS AND DISCUSSION

The reduced spectra from the *Copernicus* observations of 1976 and 1978 are displayed in Figure 2. The 15% reduction in total Lyα flux seen in the later observation may not be real because of a 20% uncertainty in the time decay of the efficiency of the U1 tube (Upson 1979). More significant is the failure in 1978 to reobserve the narrow feature identified as deuterium absorption by Dupree, Baliunas, and Shipman (1977) in the 1976 spectrum. Indeed, as discussed further below, the greatest discrepancy between the two spectra occurs near the predicted position of interstellar deuterium at 1215.32 Å. It should be noted that about 10% of the scans in each observation were interrupted near this wavelength after completing a single "standard routine" (14 spectral steps). The effect of these interruptions can be seen in Figure 2 as "glitches" in the total background rate. These glitches would be reflected in the final line profile, if the absolute background level were not adequately known. This does not appear to be the case here, since we find that removal of the interrupted scans makes only a marginal change in the line profile.

The final summed *IUE* spectrum is displayed in Figure 3 along with both *Copernicus* spectra degraded to the *IUE* resolution. The data sets have been shifted in wavelength and normalized in flux to obtain the best fit with the 1976 spectrum. The normalization factors and wavelength shifts required are well within instrumental uncertainties. The excellent overall agreement of the three spectra indicates that the observed profile is not sensitive to any chromospheric variations in the intrinsic stellar emission. (The details of the chromospheric self-reversal are probably washed out by interstellar absorption.)

The presence of interstellar deuterium absorption in the *IUE* spectrum can be seen by reflecting the red wing of the profile about the center of symmetry defined by the line wings. However, because hydrogen absorption cuts the stellar emission asymmetrically, the reflected red wing must be extrapolated if it is to be used to define a continuum to derive an equivalent width. Since deuterium absorption occurs near the blue emission peak, this extrapolation is quite uncertain. Thus
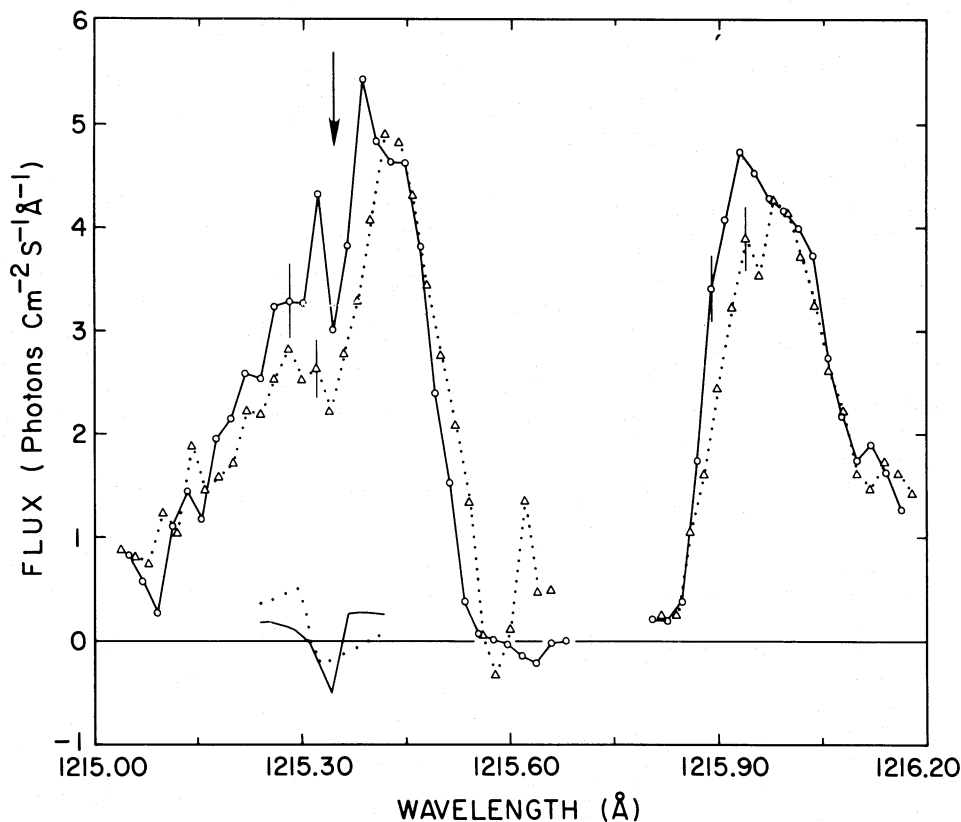
FIG. 2.—The Lyα line of α Cen A as observed with the *Copernicus* satellite in 1976 (*solid line*) and in 1978 (*dotted line*). There have been no normalizations or wavelength shifts, but points contaminated by geocoronal emission have been deleted. The arrow points to the feature identified as deuterium absorption by Dupree *et al.* (1977) in the 1976 spectrum. Also indicated below are the fluctuations in the background level for each spectrum, near the vicinity of the expected interstellar D I feature.

all results in this paper are based on the model-fitting procedure described previously.

Figure 4 shows the 90% confidence contours of allowed values in the $n_{H I}$–$b_{H I}$ plane for each of the three observations. This contour plot is derived from a grid of χ^2 values according to the procedure of Anderson *et al.* (1978). As noted by McClintock *et al.* (1978), the square-well shape of the absorption profile permits a large range of hydrogen column densities to be consistent with the data. We can only conclude from these data that $b_{H I} > 11$ km s^{-1}.

A slightly better handle on the interstellar hydrogen density can be obtained by consideration of the absolute stellar Lyα flux, and of the similarity between α Cen A and the Sun (Ayres and Linsky 1980). Ayres *et al.* (1982) have presented emission fluxes for several far-ultraviolet chromospheric lines, using the same *IUE* observations used here. Their values fall within the range of appropriately scaled values, for solar minimum and maximum activity (Mount and Rottman 1981). If we assume that the Lyα emission of α Cen A also falls within the range of solar values (2–5×10^{11} photons cm^{-2} s^{-1} at 1 AU), then our models require that 0.03 cm$^{-3} < n_{H I} < 0.27$ cm^{-3}.

Our model-fitting procedure centers deuterium at its isotopic shift (0.332 Å) from the center of the hydrogen absorption profile. It became apparent that a much better fit could be obtained to both the 1978 *Copernicus* and *IUE* data if the deuterium feature were blueshifted 8 km s^{-1} (0.032 Å) from its predicted position (Fig. 5). Best-fit models with and without the

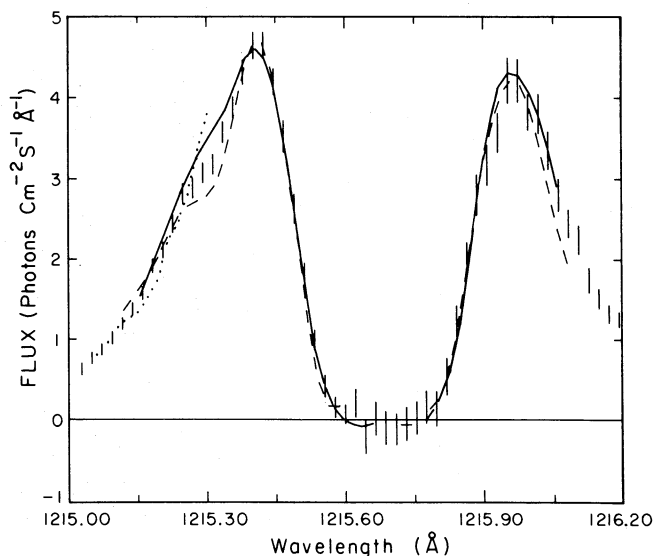FIG. 3.—The reduced *IUE* Lyα profile (*error bars*) is compared with the *Copernicus* spectra of 1976 (*solid line*) and 1978 (*dashed line*). The *Copernicus* spectra have been smoothed to the resolution of the *IUE*. The *IUE* absolute calibration has been multiplied by 1.25, while the 1978 *Copernicus* spectrum has been blueshifted 0.02 Å, and multiplied by 1.15. The dotted line shows the red wing of the *IUE* profile reflected through the center of symmetry (as defined by the far wings) into the blue. The asymmetry between the blue and red wings is due to deuterium absorption near 1215.32 Å. Caveats concerning the *IUE* line profile uncertainties are given in the text.
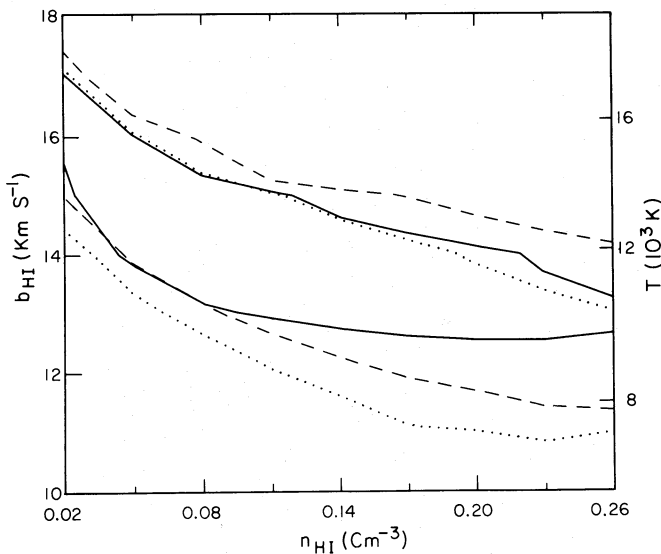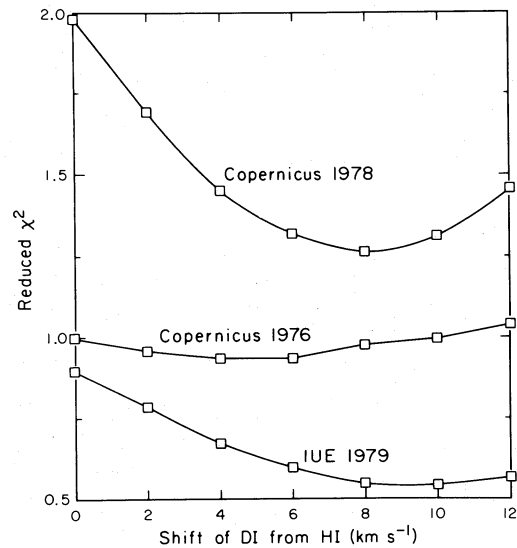
FIG. 4

FIG. 5

FIG. 4.—The 90% confidence contours for permitted values in the n_{HI}–b_{HI} plane are shown for the 1976 *Copernicus* (*solid line*), 1978 *Copernicus* (*dashed line*), and *IUE* (*dotted line*) observations. It is not possible to determine uniquely a hydrogen density; however, the velocity dispersion b_{HI} must be greater than 11 km s^{-1}.

FIG. 5.—The reduced χ^2 of the best fit model for each of the three observations is shown as a function of the assumed blueshift of D I from the position predicted on the basis of its isotopic shift from the observed center of H I absorption.
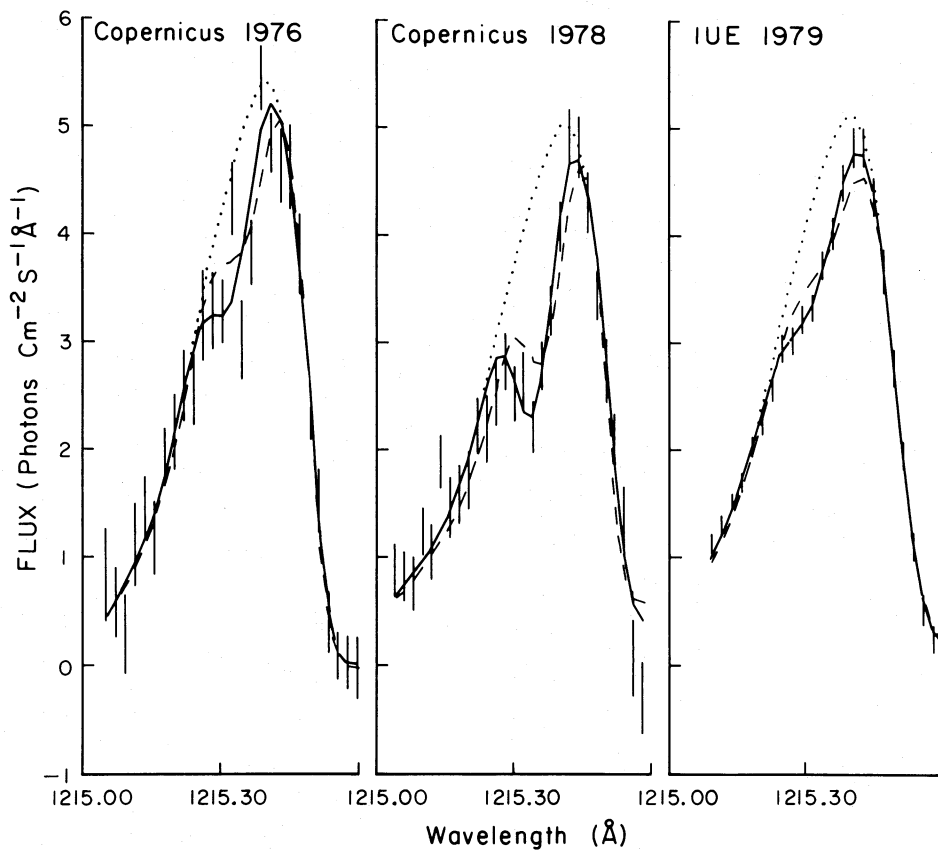

FIG. 6.—The blue wing of the Lyα line is shown for each of the three observations (*error bars*), together with best fits (of the entire profile) from our modeling. The dashed line assumes interstellar D I absorption occurs at its isotopic shift (0.332 Å) from the center of H I absorption. An improvement in χ^2 can be made by blueshifting the deuterium feature an extra 8 km s^{-1} (*solid line*). The dotted line has the same parameters as the solid line fit, but with D I absorption removed from the model. All the fits shown here have assumed $n_{HI} = 0.1$ cm^{-3}.

blueshift are shown in Figure 6. A good fit can be made to the 1976 *Copernicus* data with or without blueshifting the deuterium absorption. However, if the single high datum at 1215.30 Å were removed, the 1976 data would also show a χ^2 minimum near a blueshift of 8 km s^{-1}.

We emphasize that the results shown here do not depend on a precise absolute wavelength scale. The center of the stellar emission is determined by fitting to the line wings, while the center of the interstellar hydrogen absorption is well determined from its square-well–shaped profile. However, our derived interstellar bulk velocities do depend on the profile assumed for the intrinsic stellar emission. We have tried to estimate this effect by introducing as a parameter a simple linear asymmetry in the stellar emission, as is sometimes seen in the solar Lyα profile (Vidal-Madjar 1977). A moderate asymmetry (blue peak/red peak = 1.1) is consistent with the data, and a broader range of H I bulk velocities is then permitted. However, the shape of the curves in Figure 5 is not significantly altered, and there still is a need for distinct bulk velocities of H I and D I.

A possible explanation for the apparently different bulk velocities of hydrogen and deuterium is an interstellar medium with at least two components at different temperatures and velocities. The cool component would be detectable only in the unsaturated deuterium profile. There is, as yet, no direct evidence for cool, dense material in the nearby interstellar medium; however, the maps of Bruhweiler (1982) and Frisch and York (1983) do indicate a density gradient within a few parsecs of the Sun. In addition, Paresce (1983) has suggested the existence of condensations with $n_{\rm H I} > 1$ cm^{-3} along the line of sight to α Oph ($d = 16.7$ pc, $l^{\rm II} = 32°$, $b^{\rm II} = 23°$). A non-uniform interstellar medium may also explain the larger velocity dispersion seen toward α Cen than, for example, along the line of sight toward Capella ($b_{\rm H I} < 10$ km s^{-1}; McClintock *et al.* 1978). However, Oegerle *et al.* (1982) observed only one interstellar component of Mg II along the line of sight to α Cen. Their derived bulk velocity for Mg II (+10 km s^{-1}) in the stellar rest frame agrees with our neutral hydrogen measurements, and with the projection of the flow velocity of the interstellar wind through the solar system.

There are several alternative explanations for the apparent velocity shift of deuterium relative to hydrogen. Vidal-Madjar *et al.* (1978) actually predicted different bulk velocities for D I and H I (see also Bruston *et al.* 1981). Their argument is based on the anisotropic far-ultraviolet radiation field in the solar neighborhood, and a selective radiation pressure acting on deuterium. However, the predicted velocity shift between D I and H I is only 200 cm s^{-1}, so their model cannot account for the present observations without major modifications. Another possibility is blending with a weak absorption produced by neutral hydrogen in an 80 km s^{-1} component of the stellar wind. Such components are seen in hot star winds, but there is no evidence yet for their existence in cool dwarf winds. Finally, we note that our best-fit velocity for the deuterium feature is only +2 km s^{-1} with respect to the stellar emission, perhaps indicating a stellar origin. However, deuterium is expected to be processed in stars, and is not seen in the solar Lyα profile.

With uncertainties about both the structure of the interstellar gas toward α Cen and the hydrogen density, it is difficult to derive accurate values for $n_{\rm D I}/n_{\rm H I}$. Assuming a uniform interstellar medium, however, we can rule out the low values [$n_{\rm D I}/n_{\rm H I} = 2.4(+0.12, -0.07) \times 10^{-6}$] derived by Dupree, Baliunas, and Shipman (Fig. 7). The *IUE* data, while giving

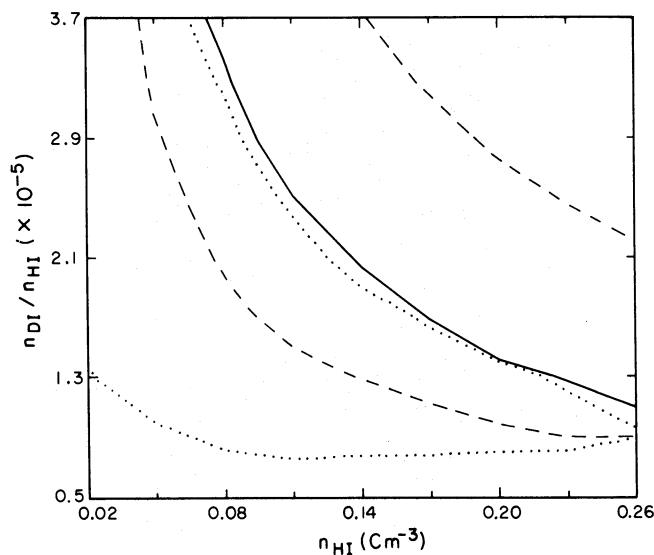FIG. 7.—Same as Fig. 4, only now in the $n_{\rm H I}$–($n_{\rm D I}/n_{\rm H I}$) plane. The 1976 *Copernicus* observation permits any value of $n_{\rm D I}/n_{\rm H I}$ below the solid line. However, the other two observations place a lower limit of $n_{\rm D I}/n_{\rm H I} > 8 \times 10^{-6}$, with higher values more likely.

results entirely within the 1976 *Copernicus* 90% confidence contours, place the stronger limits $n_{\rm D I}/n_{\rm H I} > 0.8 \times 10^{-5}$, and $n_{\rm D I}/n_{\rm H I} < 2.7 \times 10^{-5}$ if $n_{\rm H I} = 0.1$ cm^{-3}. The 1978 *Copernicus* data require a higher $n_{\rm D I}/n_{\rm H I}$ ratio, with best-fit values greater than 2×10^{-5}. In general, the $n_{\rm D I}/n_{\rm H I}$ values derived for the 1978 spectrum are about twice those of the 1976 spectrum. However, the 90% confidence contours for the two data sets overlap, so this difference may be due to statistical fluctuations in the observed spectra.

Recently, Vidal-Madjar *et al.* (1983) have reevaluated the $n_{\rm D I}/n_{\rm H I}$ determinations derived from the atomic Lyman absorption lines in the spectra of hot stars within 1 kpc of the Sun. They concluded that the $n_{\rm D I}/n_{\rm H I}$ ratio toward these stars is likely less than 5×10^{-6}. This value is in disagreement both with the lower limit derived here toward α Cen A($n_{\rm D I}/n_{\rm H I} > 8 \times 10^{-6}$) as well as with four other determinations of $n_{\rm D I}/n_{\rm H I}$ in the immediate vicinity of the sun (see summary in Bruston *et al.* 1981). The only low $n_{\rm D I}/n_{\rm H I}$ value determination toward a late-type star is for λ And ($n_{\rm D I}/n_{\rm H I} = 1.3$–$5 \times 10^{-6}$, Baliunas and Dupree 1979), but their analysis was hampered by noisy scans and geocoronal contamination.

V. CONCLUSIONS

We have demonstrated that high-dispersion, large-aperture *IUE* spectra may be used to study the Lyα profile of nearby stars. There is excellent overall agreement between the *IUE* and *Copernicus* observations of α Cen A. The deuterium feature appears stronger in the 1978 *Copernicus* observation than in the other two, but the derived 90% confidence intervals for the three observations overlap.

We are unable to place strong limits on $n_{\rm H I}$ along the line of sight toward α Cen A. However, for any assumed $n_{\rm H I}$, we can place limits on $b_{\rm H I}$, $n_{\rm D I}/n_{\rm H I}$, and the stellar Lyα flux. For example, if $n_{\rm H I} = 0.1$ cm^{-3}, then $b_{\rm H I} = 13$–15 km s^{-1}, $n_{\rm D I}/n_{\rm H I} = 0.8$–$2.7 \times 10^{-5}$, and the stellar Lyα flux corresponds to "moderate solar activity." Both of the previously unpublished observations require $n_{\rm D I}/n_{\rm H I} > 8 \times 10^{-6}$, regardless of the value of $n_{\rm H I}$.

A better fit model to each of the three observations can be made by blueshifting interstellar D I by 8 ± 2 km s^{-1} from its predicted isotopic position. This result does not appear to be an artifact due to an intrinsic asymmetry in the stellar emission. A likely explanation for the shift is in terms of an interstellar medium with at least two components at different velocities and temperatures.

The High Resolution Spectrometer (HRS) on Space Telescope should be able to resolve many of the ambiguities associated with the Lyα line in α Cen A. Meanwhile, high-dispersion *IUE* spectra can be used to probe the lines of sight to other active-chromosphere stars in the immediate solar neighborhood. Of special interest is α Cen B (K1 V), where the interstellar parameters should be identical to those derived here.

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