*Recent Insights into the Physics of the Sun and Heliosphere:
Highlights from SOHO and Other Space Missions
IAU Symposium, Vol. 203, 2001
P. Brekke, B. Fleck, and J. B. Gurman eds.*

HST Observations of Heliospheric and Astrospheric Lyα Absorption Toward the α Cen System

B. E. Wood, J. L. Linsky

JILA, University of Colorado and NIST, Boulder, CO 80309-0440, USA

J. A. Valenti

STScI, 3700 San Martin Dr., Baltimore, MD 21218, USA

Abstract. We use HST observations of the nearest star system (the α Cen system) to search for Lyα absorption from both heliospheric material around the Sun and analogous astrospheric material around the stars which has been heated by the collision between the solar/stellar winds and the interstellar medium. For α Cen A and B, both heliospheric and astrospheric absorption are detected, whereas for α Cen's distant companion star Proxima Cen only heliospheric absorption is detected, suggesting that Proxima Cen's astrosphere must be smaller and its wind therefore weaker than that of α Cen. Based on observations of these stars taken many years apart, we find that neither the heliospheric absorption nor the astrospheric absorption detected toward α Cen AB varies significantly.

Models of the interaction between the solar wind and local ISM predict that charge exchange processes should create a population of heated neutral hydrogen gas throughout the heliosphere (e.g., Baranov & Malama 1995). This material produces a detectable absorption signature in the Lyα lines of nearby stars with low interstellar column densities. Such spectra have therefore been used to study the properties of neutral hydrogen in the outer heliosphere, and also to detect analogous "astrospheric" hydrogen surrounding other stars (Wood & Linsky 1998). The first of these Lyα absorption studies was from observations of the very nearby ($d = 1.34$ pc) binary system α Cen AB (G2 V+K0 V).

Both α Cen A and B were observed with the GHRS instrument on board the *Hubble Space Telescope* (HST) in 1995 May. The observations included high resolution observations of the H I Lyα line (see Fig. 1a), which contains broad absorption from interstellar H I and narrower absorption from interstellar deuterium (D I). Linsky & Wood (1996) found that the properties of the H I Lyα absorption were inconsistent with the properties of D I and other ISM lines in the α Cen spectra. The dashed line in Figure 1a shows the H I absorption that results when H I is forced to have a central velocity and Doppler broadening parameter consistent with the other ISM lines. Excess absorption is present on both sides of the line. Linsky & Wood (1996) proposed that heated heliospheric and/or astrospheric H I was responsible for the excess. Gayley et al. (1997) demonstrated that hydrodynamic models of the heliosphere could reproduce the excess absorption on the red side of the ISM absorption, but only astrospheric material could account for the blue side excess (see Fig. 1a).

https://doi.org/10.1017/S0074180900220081 Published online by Cambridge University Press

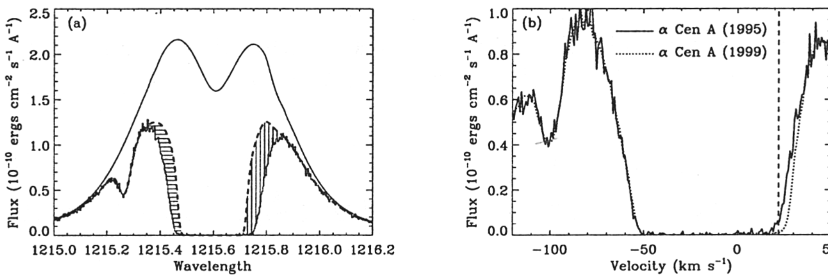

Figure 1. (a) HST/GHRS Lyα spectrum of α Cen B, showing broad H I absorption at 1215.6 Å and D I absorption at 1215.25 Å. The upper solid line is the assumed stellar emission profile and the dashed line is the ISM absorption alone. The excess absorption is due to heliospheric H I (vertical lines) and astrospheric H I (horizontal lines). (b) Comparison of the Lyα absorption observed by HST toward α Cen A in 1995 (solid line) and 1999 (dotted line). The expected location of geocoronal absorption for the 1999 data is shown as a dashed line.

In 1999 February, α Cen A was observed again by HST, this time by the STIS instrument which replaced GHRS in 1997. A year later in 2000 May, STIS observed α Cen's distant (about 12,000 AU away) companion star Proxima Cen (M5.5 Ve). Figure 1b shows a comparison of the two α Cen A spectra. The data agree very well on the blue side of the absorption line, indicating that the α Cen astrospheric absorption did not change between 1995 and 1999.

The 1999 data show more absorption on the red side, which would seem to suggest variability in the heliospheric absorption, but unfortunately the 1999 spectrum was taken at a time when geocoronal absorption was also centered along the red side of the line (see Fig. 1b), so we suspect that the Earth's geocorona is responsible for the extra absorption. This conclusion is confirmed by Figure 2, which shows that the 1995 α Cen B and 2000 Proxima Cen spectra are identical on the red side of the line. The 1995 data were taken close to the minimum of the Sun's activity cycle, while the 2000 data were taken close to solar maximum. Apparently, the structure of the outer heliosphere does not vary significantly during the solar activity cycle. This result is consistent with the models of Zank (1999), which predict little variability for global H I properties in the outer heliosphere, despite the fact that the solar wind ram pressure varies by about a factor of 2 on these timescales (Richardson 1997).

The comparison of the Proxima Cen and α Cen B Lyα spectra in Figure 2 shows that Proxima Cen has significantly less absorption on the blue side of the line. In fact, there is no detectable astrospheric absorption toward Proxima Cen, in contrast to α Cen. Proxima Cen is far enough away from α Cen that it will not share an astrosphere with α Cen A and B. However, it is not so far away that the properties of the ISM surrounding the stars should be very different, so differences in stellar wind properties must be responsible for the difference in astrospheric absorption. In particular, the significantly lower astrospheric H I column density of Proxima Cen suggests a much smaller astrosphere, which in

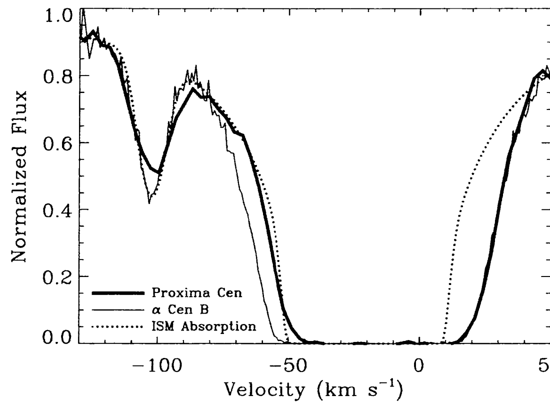

Figure 2. The α Cen B Lyα spectrum (thin solid line) and inferred ISM absorption (dotted line) are compared with a lower resolution STIS spectrum of α Cen's distant companion Proxima Cen (thick solid line).

turn suggests that Proxima Cen's wind is much weaker than that of α Cen AB. To be more precise, Wood et al. (2000) have estimated from these data that Proxima Cen's mass-loss rate is at least a factor of 10 lower than α Cen's.

A lower mass-loss rate for Proxima Cen is not surprising given the fact that Proxima Cen is much smaller and dimmer than the α Cen stars. However, Proxima Cen's wind is accelerated in a corona that is very active, producing large flares and with a quiescent X-ray luminosity about equal to that of α Cen A and B (Hünsch et al. 1999). Thus, one might have expected that Proxima Cen's wind should be as strong or stronger than that of α Cen AB, but our observations suggest that this is not the case.

Acknowledgments. Support for this work was provided by NASA grants NAG5-9041 and S-56500-D to the University of Colorado, and also by an NSF travel grant administered by the American Astronomical Society.

References

Baranov, V. B., & Malama, Y. G. 1995, J. Geophys. Res., 100, 14755

Gayley, K. G., Zank, G. P., Pauls, H. L., Frisch, P. C., & Welty, D. E. 1997, ApJ, 487, 259

Hünsch, M., et al. 1999, A&AS, 135, 319

Linsky, J. L., & Wood, B. E. 1996, ApJ, 463, 254

Richardson, J. D. 1997, Geophys. Res. Lett., 24, 2889

Wood, B. E., & Linsky, J. L. 1998, ApJ, 492, 788

Wood, B. E., Linsky, J. L., Müller, H. -R., & Zank, G. P. 2000, ApJ, in press

Zank, G. P. 1999, in Solar Wind 9, ed. S. R. Habbal, et al. (New York: AIP), 783