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THE DISTRIBUTION OF ATOMIC HYDROGEN IN THE JOVIAN ATMOSPHERE

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We present an analysis of the Voyager and IUE Lyman alpha spectra of the Jovian equatorial emission in which we derive a zonal asymmetry in the hydrogen column abundance. Using two estimates of the fraction of Lyman alpha which is due to direct excitation by charged particle precipitation from the ionosphere, we have derived upper and lower limits to the H column abundance within and without the perturbed region. We show that the asymmetry in H abundance may be due to localized heating near the homopause with a consequent rise in scale height. The derived exospheric temperature remains fairly constant with longitude. The required additional heat input over the bulge region, 0.02 erg cm^{-2} s^{-1}, is supplied by an additional flux of magnetospheric electrons due to Jupiter's magnetic anomaly.

Voyager ultraviolet spectrometer data indicated a strong longitudinal variation in the Lyman alpha brightness of Jupiter (Sandel *et al.*, 1980). An enhancement was situated at about 110 deg W longitude and exhibited a brightness of 20-21 kR in contrast to the 15-16 kR level for remaining longitudes. The perturbation shows up as well on the night side, although the total magnitude of the intensity is reduced by a factor of about 20. The feature was observed as well by IUE (Skinner *et al.*, 1983) over a period of three years starting in 1978. The Lyman alpha bulge persisted, but was highly variable. We note that the brightness for the perturbed region in the IUE data was 9-15 kR compared to a level 8.5 kR elsewhere. These lower values compared to those from Voyager suggest the possibility of a calibration difference. Nevertheless, the observations show that the feature does persist, and the IUE results show that it is variable.

Our analysis of the Lyman alpha data indicates that the anomalous peak in brightness is due in part to a zonal asymmetry in the hydrogen column abundance. The sources of Lyman alpha that we've considered include reflected interplanetary Lyman alpha, direct excitation by charged particles, and, on the day side, resonance scattering of solar Lyman alpha. It is recognized that a longitudinal variation in the direct excitation by charged particles is one source for the Lyman alpha peak (cf. Gladstone and Shemansky, 1983; Shemansky, 1985). The magnitude of the particle excitation source is taken from the estimates by Shemansky. There is a source which seems to be constant in longitude with a magnitude of 2.5-3 kR, and a source variable in longitude and time with a magnitude of order 4 kR. The longitudinal variation in the charged particle flux is attributed to the magnetic anomaly. Mirror points for charged particles are lowered in the magnetic anomaly region, causing enhanced conductivity. The E-cross-B forces cause a flow of charged particles away from the active sector, and these particles return in the region of the Lyman alpha bulge (cf. Dessler *et al.*, 1981; Hill *et al.*, 1981).

So what we have done is use two different estimates of the amount of Lyman alpha emission due to particle excitation. We next subtract this flux from the total observed to determine the flux due to resonance scattering of solar Lyman alpha, which in turn permits us to infer the enhanced column density of atomic hydrogen required to explain the Lyman alpha bulge. Now, if you assume that the amount of Lyman alpha which is due to particle excitation is constant with longitude, then you will conclude that the column density of atomic hydrogen varies by a factor of three with longitude. However, if you assume instead that there is a particle flux source of 3 kR in the normal component and 7 kR in the bulge, you will conclude that there is a 50 percent enhancement of the column density in the bulge region. Similarly, if you assume that the particle flux source is constant, then the column varies by a factor of 2.5 with time. But if you assume instead that it is the exospheric source that is varying, then you find that no variation in the columm density with time is necessary.

We looked at the night side Lyman alpha and using the hydrogen distribution determined from the analysis of the dayside data, we estimate that about one-third of the nightside Lyman alpha flux is due to resonance scattering of interplanetary Lyman alpha. The remainder should be entirely due to direct excitation by charged particles. Analysis of the variation of Lyman alpha for the nightside suggests that both a zonal variation in column density of hydrogen and particle flux must be present. Furthermore, if one assumes that the particle source is constant with longitude, then an enhancement of about 100 K in the mesospheric temperature of the bulge region is implied. We believe that this is unrealistic, again supporting a variation in the direct excitation by charged particles.

REFERENCES

Dessler, A. J., B. R. Sandel, and S. K. Atreya (1981). The Jovian hydrogen bulge: Evidence for co-rotating magnetospheric convection. *Planet. Space Sci.* 29, 215-224.

Hill, T. W., A. J. Dessler, and L. J. Maher (1981). Corotating magnetospheric convection. *J. Geophys. Res.* 86, 9020-9028.

Sandel, B. R., A. L. Broadfoot, and D. F. Strobel (1980). Discovery of a longitudinal asymmetry in the H Lyman-alpha brightness of Jupiter. *Geophys. Res. Lett.* 7, 5-8.

Shemansky, D. E. (1985). An explanation for the H Ly α longitudinal asymmetry in the equatorial spectrum of Jupiter: An outcrop of paradoxical energy deposition in the exosphere. *J. Geophys. Res.* 90, 2673-2694.

Skinner, T. E., S. T. Durrance, P. D. Feldman, and H. W. Moos (1983). Temporal variation of the Jovian HI Lyman-alpha emission (1979-1982). *Astrophys. J.* 265, L23-L27.

DR. TRAFTON: What can you say about the alternative explanation that the hydrogen was formed over the magnetic pole and drifted down the bulge region by centrifugal force?

MS. KILLEN: Well, I think if that were the case, then the line would show variation along the equator. Isn't that true?

DR. TRAFTON: Yes, that would be the bulge. That was an early alternative explanation.

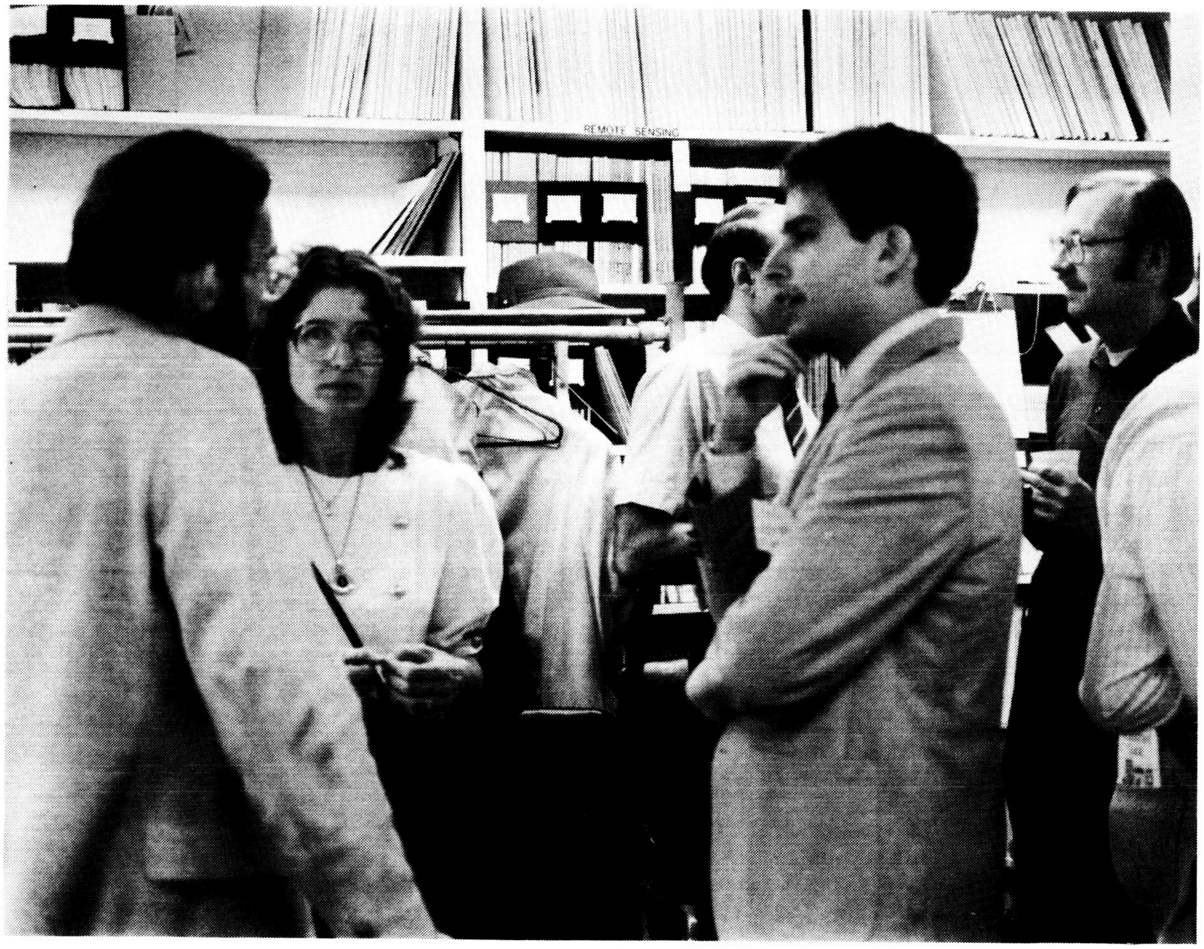
MS. KILLEN: Well, I think the problem with that is the variation is along the particle drift equator. The variation follows the particle drift equator rather than the true equator.

DR. TRAFTON: Did you find that your mechanism adequately explains this observed tendency?

MS. KILLEN: Yes, if it is coupled with an exospheric source.

DR. STROBEL: I have a number of comments. (1) The Voyager data was given for the center of the disk intensity. The disk averaged intensity is two-thirds of this value and thus in agreement with IUE. (2) If you examine where the major particle precipitation occurs in the auroral regions and assume particle heating drives a thermospheric wind system to transport hydrogen to the bulge region, you encounter a problem. Ion drag will direct transport along flux tube paths, but the field is so contorted when you're in close to Jupiter, you can't get hydrogen to the right spot: the bulge region. I guess that makes a difference. The third comment is that Don Shemansky has written a paper, which just came out, in which he argues that in reanalyzing the Voyager UV data the particle precipitation is actually stronger in the anti-bulge region than in the bulge region.

MS. KILLEN: I think that's only a certain part. It's not all of the particle precipitation.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