AN OBSERVATION OF JUPITER IN THE ULTRAVIOLET

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A single spectral scan of Jupiter in the ultraviolet was obtained from an Aerobee rocket on July 23, 1963 at 08^{h}02^{m}U.T. The observation was made with an objective grating stellar spectrometer similar to those described by Stecher and Milligan (1962). The spectral range was from λ1700 to λ4000 with 55 Angstrom resolution. The instrument had been calibrated in the laboratory prior to flight so that the absolute flux above the earth's atmosphere was obtained at each point in the spectrum. The accuracy of the flux measurement was primarily determined by the noise in signal which was worse than one would like.

The geometrical reflectivity, p, as a function of wavelength is presented in Figure 1. This was obtained by using the solar flux values given by Tousey (1963) and the appropriate Ephemeris values for the necessary geometry. Jupiter was nearly at quadrature when the observation was made.

If we assume Jupiter has a Rayleigh atmosphere in the ultraviolet above the cloud layer, we may immediately obtain upper limits for the column density of any species if the reflectivity is known in terms of optical depth, τ. Using the tables computed by Coulson, Dave and Sekera (1960), curves in the p-τ plane were constructed by numerical integration. Additional curves were obtained for isotropic scattering from the available X-Y functions given by Mayers

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(1962) and by Sobuti (1963). These were used to approximate Rayleigh scattering for $\tau > 1$.

The total number of atoms or molecules in a cm^2 column perpendicular to the cloud layer is now obtained from $\tau = n\sigma$ under the assumption of only one constituent. Here n is the number of atoms or molecules and σ is the Rayleigh scattering cross section per atom or molecule. The Rayleigh scattering cross section for molecular hydrogen is given by Dalgarno and Williams (1962). In Figure 1 three atmospheres of molecular hydrogen are presented each with the assumption of zero reflectivity for the cloud tops. The 27 km. atm. is that of Spinrad and Trafton (1963) obtained from the H_2 quadrupole bands. The 4.6 km. atm. is that of Zabriskie (1962) which is also from the H_2 quadrupole bands. The 10.5 km. atm. is the one that best fits the reflectivity measurements. An all helium atmosphere which would produce the same reflectivity would be about 200 km. atm. and can probably be ruled out by pressure considerations (Spinrad and Trafton 1963).

The above analysis is based on coherent scattering. In the case of most molecular gases including molecular hydrogen this is known not to be the case. Raman scattering from H_2 is one-twentieth of Rayleigh scattering at $\lambda 1216$ (Dalgarno and Williams, 1962). Isotropic scattering may be used to approximate this effect by setting the particle albedo equal to 0.95 and comparing it with the result for a particle albedo of unity. In the case of an optically thick atmosphere (Harris 1961) one concludes that 43% of the incident photons emerge in the Raman lines. The effect here which depends on the cross section for Raman scattering in the 2000 to 3000 Angstrom range would be to decrease the reflectivity and give the appearance of less atmosphere.

The absorption feature between $\lambda 2400$ and $\lambda 2700$ is of course unidentified. If for the sake of conjecture it is

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assumed to be the forbidden photodissociation of molecular hydrogen, an empirical absorption coefficient may be derived. This may be done by following the path of the photon with isotropic scattering. A particle albedo of unity is equated numerically to the Rayleigh scattering cross section and the particle albedo giving the observed mean absorption depth is determined. The ratio then gives the cross section which is on the order of 10^{-27} cm^2 assuming all H_2.

Below λ2000 the solar continuum is so weak that no reliable determination of the reflectivity can be made. It appears to be zero which is reasonable since absorption of ammonia begins at 2100A and results in almost continuous absorption at shorter wavelengths reaching an optical depth of 10^5 at λ1216 (Kuiper, 1952) (Watanabe, et al., 1953).

One is tempted to make the speculation that Raman scattering can account for the ultraviolet decrease in Uranus and Neptune. The reflectivity curves of these planets reported here two years ago by Younkin and Münch (1962) give the appearance of a conservative Rayleigh atmosphere reduced in the near ultraviolet by the redistribution of scattered radiation by Raman scattering. This assumes that the Raman H_2 scattering coefficient is about two percent that of the Rayleigh scattering coefficients.

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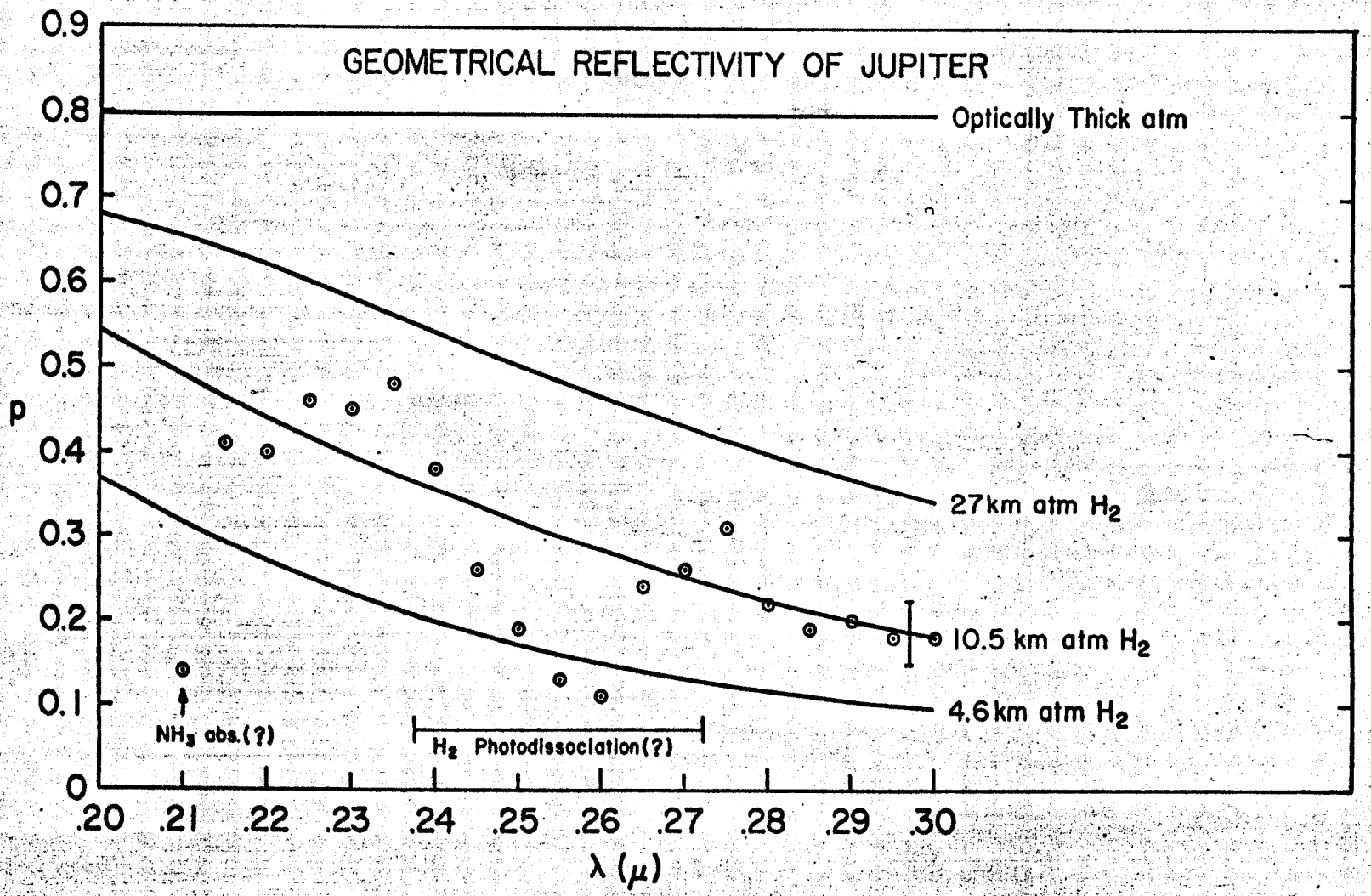
The observed geometrical reflectivity of Jupiter, p, as a function of wavelength. The best fit is the 10.5 km.atm. of H_2. The other curves are those of other investigators.


GEOMETRICAL REFLECTIVITY OF JUPITER
Optically Thick atm
27km atm H_2
10.5 km atm H_2
4.6 km atm H_2
NH_3 abs.(?)
H_2 Photodissociation(?)
p
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
.20
.21
.22
.23
.24
.25
.26
.27
.28
.29
.30
λ (μ)