TD1A SATELLITE SPECTROSCOPIC OBSERVATIONS OF JUPITER IN THE ULTRAVIOLET

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Abstract. Three spectra of Jupiter were recorded by TD1A satellite between 1350 and 2600 Å. From these data, the geometrical albedo of the planet was computed.

From 2600 to 2100 Å, the value of the albedo matches the simple diffusing models of Jupiter's atmosphere (Greenspan and Owen, 1967).

From 2100 to 1800 Å, a broad absorption can be assigned to NH_3 molecule (2168 Å transition).

Another absorption commences below 1800 Å. The absorbing molecule involved will be determined at a later date.

1. Introduction

Planetary ultraviolet spectroscopy, particularly for Jupiter, is based at the present time on a limited number of original measurements (Newburn and Gulkis, 1973).

Up to the present time, primary data have been published by Stecher (1965), Evans (1966), Moos *et al.* (1969), Jenkins (1969), Jenkins *et al.* (1969), Anderson *et al.* (1969), Kondo (1971), and Wallace *et al.* (1972).

The latter observations are the only ones recorded by satellite. The particular interest for such measurements is that almost no correction must be made for terrestrial atmospheric opacity.

For this reason, it has been considered of interest to show herewith three spectra of Jupiter, which were recorded from 1350 to 2600 Å by S2/68 experiment aboard TD1A (European Astronomical Satellite).

2. Experimental

Various scientific experiments are mounted aboard TD1A satellite, among which is the S2/68 telescope. This device was designed cooperatively by the Astrophysical Institute of Liége University, the Royal Observatory of Edinburgh and the Astrophysical Division of Culham Laboratory. The telescope features a 275 mm clear aperture, a three-channel spectrometer and a photometric channel.

Detailed descriptions have been published elsewhere, related to the TD1A satellite (Tilgner, 1971) and to the S2/68 experiment (Gardier *et al.*, 1973; Malaise *et al.*, 1972).

It will be simply recalled here that the spectrometer covers the range 1350–2600 Å with a resolution of 36 Å. The photometric channel records a fixed 440 Å band centered on 2800 Å.

Relative calibration of the whole instrument was made in Liége, by means of a specially built vacuum calibration bench (Jamar *et al.*, 1971). Furthermore, unique absolute calibration techniques were used (Marette, 1973) so that the measurements reported herc have an overall accuracy better than 20%.

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3. Results

The three spectra of Jupiter, which are shown in Figure 1, were recorded on March 27th 1972. At that time, the Jovian parameters were the following:

- heliocentric distance 5.203 AU
- geocentric distance 5.283 AU
- phase angle 10°.

For the sake of clarity, the zero level of the spectra was offset in the figure. The first left point of each spectrum represents the zero level.

The three curves are very similar, and this is a proof of the photometric accuracy of the observations.

Albedo calculations were performed as follows:

(a) From the three individual spectra, a best-fit curve has been defined.

(b) Solar data were taken from Broadfoot (1972)'s photoelectric spectrum for $\lambda > 2150$ Å and reduced to the S2/68 spectral resolution of 36 Å. Below 2150 Å, the data of Detwiler *et al.* (1961) have been chosen.

(c) The attenuation factor of the solar flux was computed for the path Sun-Jupiter-Earth. The former planet was treated as a Lambert disk, the diameter of which is supposed to be known. So the geometrical albedo obeys the relation:

$$\text{Albedo} = \frac{\text{measured flux}}{\text{attenuated solar flux}}\,.$$

Figure 2 shows the obtained albedo curve. Figure 3 shows the results of the calcula-

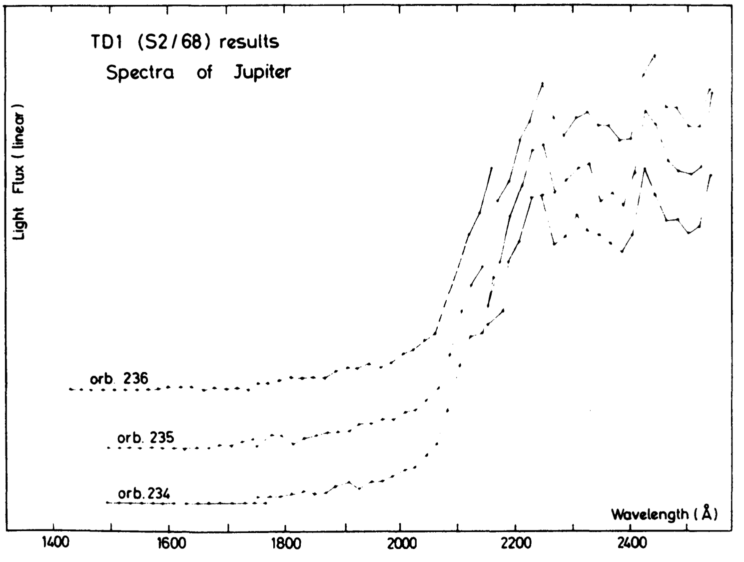

Fig. 1. Three spectra of Jupiter, recorded on March 27, 1972.

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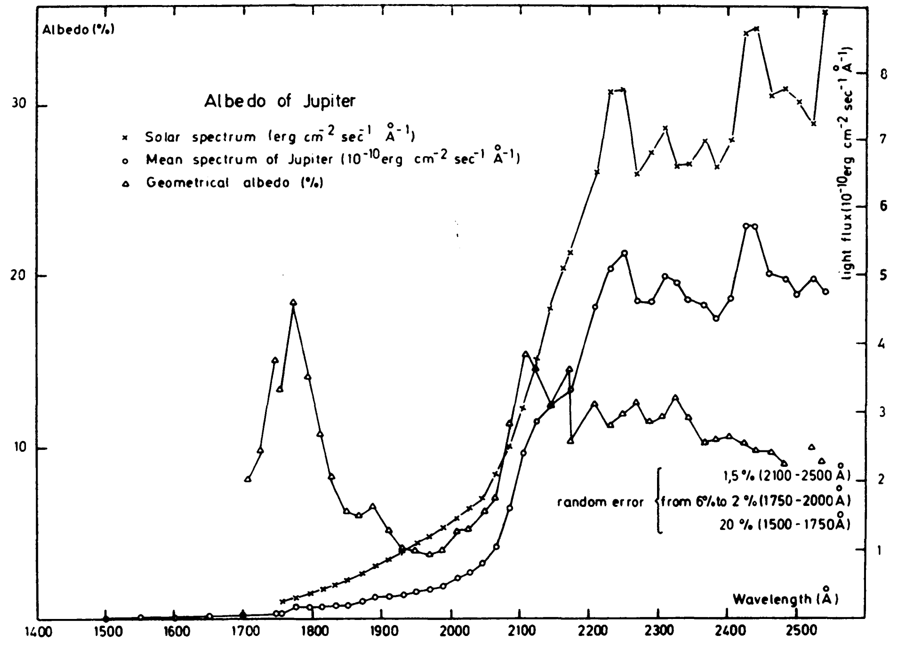

Fig. 2. Albedo of Jupiter.

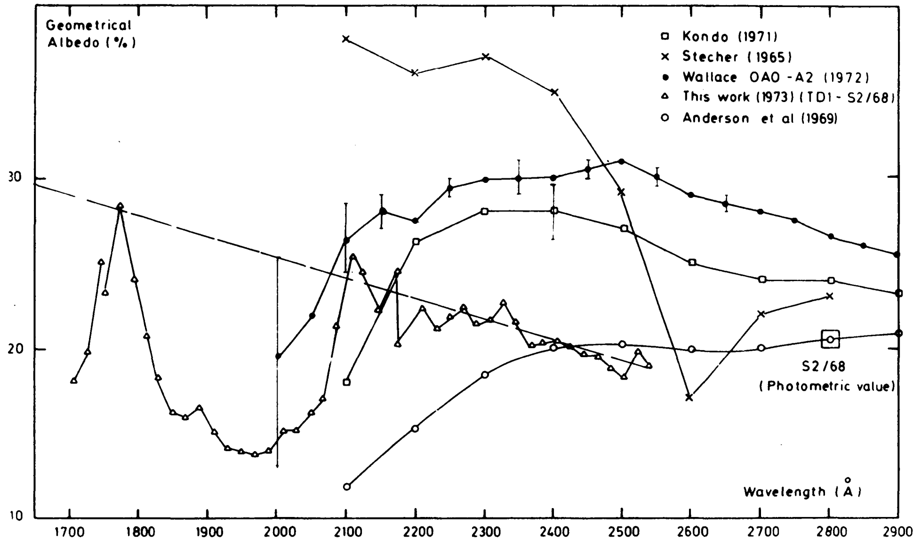

Fig. 3. Comparison of different albedo calculations. The dashed line represents the best-fit line for our observations between 2100 and 2550 Å.

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tions, together with similar data published elsewhere. It can be noticed that the curves obtained by the two satellites TD1A and OAO-2 are particularly similar in shape, whereas the absolute values from OAO-A2 are definitely greater.

Another remark to be made on our curve is related to some sawteeth which appear between 2600 and 2100 Å. These probably do not have any physical significance, although their amplitude is far greater than our measurement accuracy. Indeed, all local maxima correspond to local minima in the solar spectrum which was used.

Below 2100 Å, the albedo curve is of special interest.

(1) From 1800 to 2100 Å, a deep absorption occurs in the albedo. This absorption can undoubtedly be identified as caused by the ammonia molecule, the presence of which was proved by other means (Kuiper, 1952; Mason, 1969; Owen, 1970). This conclusion was arrived at as follows: The absorption feature ends on a local maximum, around 1770 Å. This maximum falls on a straight line which is a best-fit for the points between 2100 and 2550 Å. That such a line exists seems to confirm the well-known models of Jupiter's upper atmosphere (Greenspan and Owen, 1967), i.e. a diffusing layer located over a layer of reflecting clouds. From this reference level (the dashed line drawn on Figure 3), an absorption profile due to the NH_3 molecule, in the region 1800–2100 Å, has been computed.

In the next step we have compared this coefficient with the inverse cross section of NH_3 for the 2168 Å transition (Watanabe, 1954). Figure 4 shows the result of the comparison.

Since the curves behave similarly, the origin of the absorption must be attributed to the ammonia molecule.

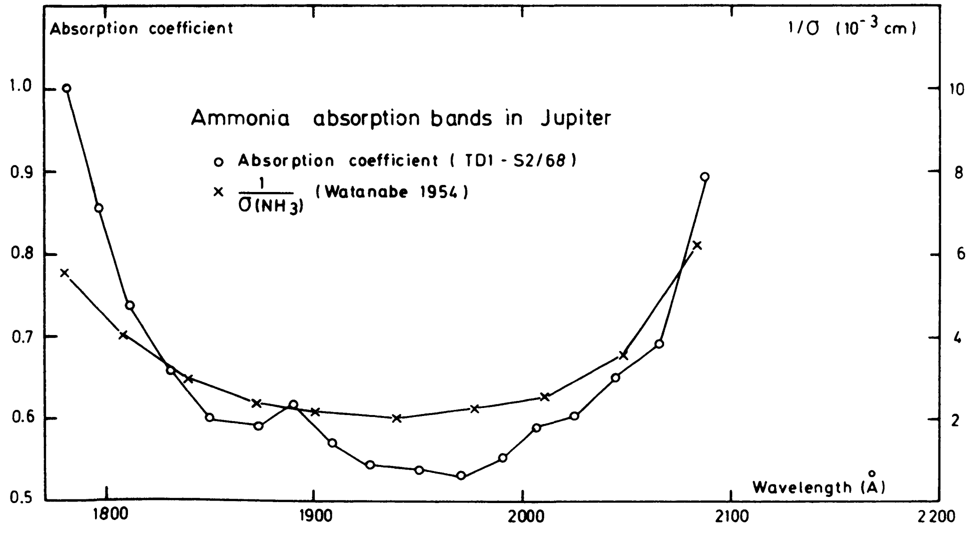

Fig. 4. Comparison of absorption coefficients obtained from NH_3 profile, calculated from the dashed-line reference level (Figure 3) with Watanabe's inverse cross section of NH_3 for the 2168 Å transition.

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(2) Figure 3 also shows a further absorption below 1770 Å. However, the measurements ranging from 1700 to 1350 Å have not been reduced yet, because of a lower signal-to-noise ratio. Nevertheless:

– this absorption feature appears to be quite real. Indeed, the detected light flux for this region is much lower than the predicted flux for a simple Rayleigh scattering atmosphere;

– further spectra of Jupiter will be soon available, so that the signal-to-noise ratio will be appreciably increased and the relevant absorbing species will be identified.

Acknowledgements

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DISCUSSION

Low: Do you not expect large scale changes in the UV albedo of Jupiter?

Duysinx: The answer will be possible only when we have computed the albedo for the sets of measurements. The set which is presented here is the first one, and we expect three or four of them.

Beer: Is the peak at 1790 Å real or is it an artefact of low signal-to-noise?

Duysinx: The peak at 1790 Å is quite real because the signal to noise ratio is still very good at that wavelength. The measured intensities were not apparent on the slide because of the linear scale used to show the whole spectrum.