TWO BRIGHT SPOTS ON SATURN'S GLOBE AS OBSERVED BY VOYAGER 2

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Abstract. Two bright spots shown by Voyager 2 images on Saturn's north temperate belt are discussed in terms of a simple photometric model in which the brightness differences are caused by obscuring matter above the main cloud layer. In the ultraviolet light, in which scattering by small particles is very effective, the spots are invisible. In the violet light they seem to be holes in the dark matter and therefore the brighter layer below it becomes visible. Also they could be rises in the bright matter. In the green light the spots are more complicated since this wavelength interval contains very strong emission spectra lines of ammonia.

1. Introduction

Dark and bright spots have occasionally been seen on Saturn's globe during the last hundred years, but the observations have only been visual while accurate measurements and descriptions are lacking. The images used in this paper (Figure 1) were taken by Voyager 2 on the 12th of July 1981 with a narrow angle camera having a resolution of about 400 km. Three different wavelengths were available: ultraviolet, violet and green, having effective wavelengths of 346.0 nm, 416.0 nm and 566.0 nm, respectively (Smith *et al.*, 1977). At that time there were two spots on Saturn's north temperate belt. Even if the images describe an instantaneous situation, some conclusions on the nature of the spots can be made.

Although the spots were smaller and had much higher latitudes than the white spots observed by Bernard, Hay, Wright, Camichel and Botham (see Alexander, 1962), they resemble each other. In particular, Hay's spot, which was also observed by Wright (1933) and was the only one of the above-mentioned spots which was observed through different filters, behaved in the same manner. For ultraviolet it could not be seen except near the central meridian. This indicates that the spots was situated below the upper atmosphere. If one also takes into account its larger size at longer wavelengths, it is possible to assume that the spot was only a hole in the darker clouds or a rise in the bright ones.

Therefore we are presently studying a model (Figure 2), in which Saturn's atmosphere is composed of a bright cloud layer and of darker matter above it. A simple calculation provides the local variations in the optical thickness of the dark matter.

2. Theory

Let the angle of incidence and reflection be ι and ϵ, respectively. If τ denotes the local optical thickness of the dark layer, the contribution of bright matter to the observed intensity is

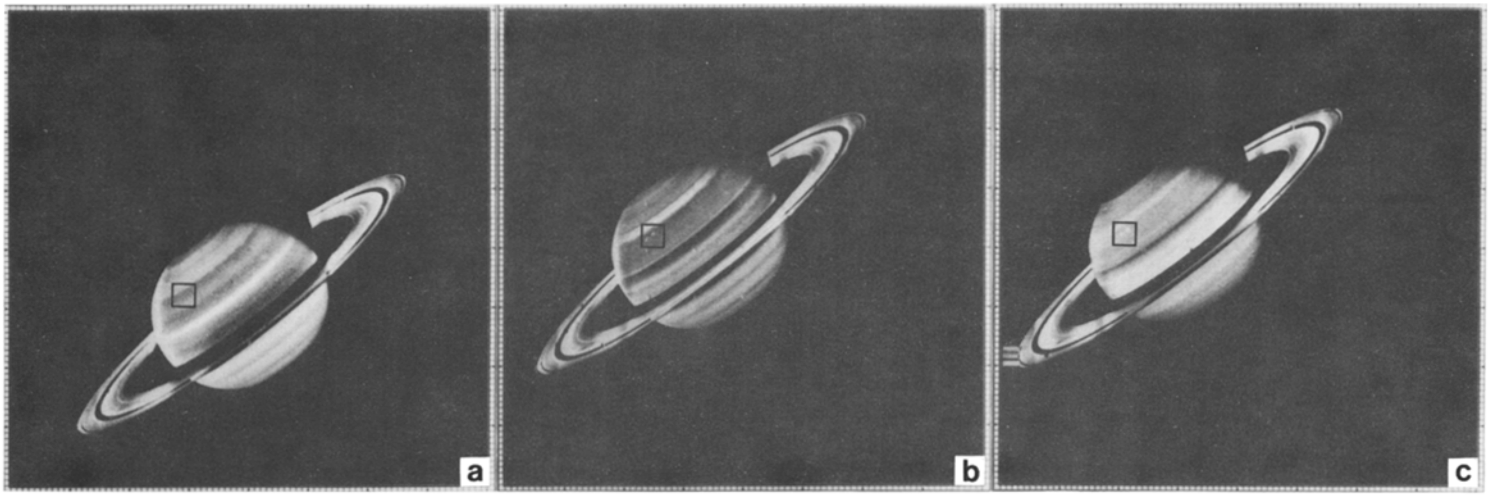


Fig. 1. Saturn on the 12th of July 1981 (a) in the ultraviolet, (b) the violet, and (c) the green light. The location of the discussed region is indicated.

Fig. 2. A schematic model of Saturn's atmosphere.

$$I_B \exp\left[-\tau\left(\frac{1}{\cos \iota}+\frac{1}{\cos \epsilon}\right)\right] , \tag{1}$$

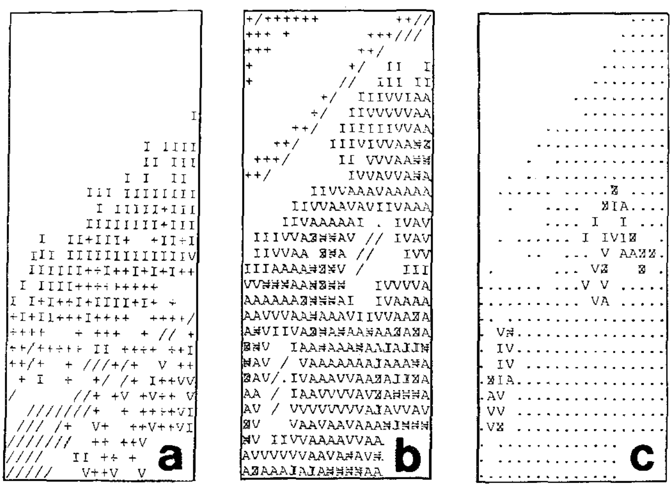
I_B being the intensity which would be found without the extinction. On the other hand, according to Lommel–Seeliger's law the single scattering in the dark layer produces the reflected intensity

$$I_D \left\{1-\exp\left[-\tau\left(\frac{1}{\cos \iota}+\frac{1}{\cos \epsilon}\right)\right]\right\} , \tag{2}$$

in which I_D corresponds to the intensity in the case $\tau = \infty$. Adding both contributions we obtain the expression

$$I = I_D + (I_B - I_D)\left\{\exp\left[-\tau\left(\frac{1}{\cos \iota}+\frac{1}{\cos \epsilon}\right)\right]\right\} , \tag{3}$$

for the observed intensity. Assuming $\tau = 0$ for the brightest regions at mid-latitudes on Saturn's globe and $\tau = \infty$ for the darkest ones, we have a means by which to determinate I_B and I_D. The optical thickness can thereafter be calculated for each point,



τ	symbol
0,0–0,2	BLANCO
0,3–0,5	·
0,6–0,8	+
0,9–1,1	/
1,2–1,4	I
1,5–1,7	V
1,8–2,0	A
2,1–2,3	H
2,4–2,6	Ɪ
2,7–	Ⅱ

Fig. 3. The optical thickness of dark matter (a) in the ultraviolet, (b) the violet and (c) the green light. The symbols are explained in the table.

$$\tau = \frac{\cos\iota\cos\epsilon}{\cos\iota + \cos\epsilon}\log\left(\frac{I_B - I_D}{I - I_D}\right). \tag{4}$$

The resulting values of τ are shown in Figure 3.

3. Discussion

The surrounding region of the spots in Figure 3 was selected to be large enough so that the north temperate belt and the next bright zone to the north (see Figure 1) are visible.

In the ultraviolet image (Figure 3a) the spots are invisible. This can be understood if the dark layer consists of small particles, which scatter short-wave radiation very effectively. However, the dark belt also shows areas having $\tau = 0$, although the corresponding spots are absent in Figures 3b (violet) and 3c (green). There might be two independent layers acting at different wavelengths, but the small particles could also cover the entire globe, both the dark belts and the bright zones, thus leading to an incorrect estimate for I_B and τ.

In the violet image (Figure 3b) the belt has a high value of τ, while there is almost no dark matter above the bright zone. The spots can be interpreted as holes which are free of obscuration except in their central regions. The other possibility are rises in the bright matter. The spots are covered by a partly transparent layer of dark matter. The bright zone at the top of the picture behaves in a similar manner: for the most part the optical thickness of the dark matter is small, but there are a few narrow streaks resembling the centres of the spots.

In the green light the spots are larger and easier to observe than for shorter wavelengths. They are bright in Figure 1c, since both spots contain a few bright areas without obscuration (blancos in Figure 3c). The centres, which are not as uniform as in the violet, are covered by an opaque layer of dark matter, but the surrounding region is semitransparent. The former phenomenon, which does not correspond to the obscuration in the violet image, may be caused by NH_3 molecules. Their emission spectrum shows a strong continuum near the effective wavelength (566.0 nm) of the filter (Robinson, 1974).

Acknowledgements

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