Polarization Measures of Jupiter and Saturn

J. S. HALL AND L. A. RILEY

Lowell Observatory, Flagstaff, Ariz.

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1. Introduction

In the spring of 1968 we observed the polarization of Jupiter in visual and UV light on 11 nights. A description of the polarimeter and of the results obtained has already been published (1968).

In this progress report, recent observations of Saturn made in the UV and visual will be presented and compared with the published Jupiter data. A few observations of the rings of Saturn will not be discussed here because their polarization is affected by scattered light from the disk. Further data will be obtained in an effort to interpret the results in a quantitative way.

It should be mentioned that the disk of Saturn has only one-quarter the area of Jupiter and is therefore a much more difficult object to observe. Even though a two-channel system is used, guiding and seeing errors, in addition to scattered light, tend to decrease the effective resolution. Also, the ring system introduces scattered light and occulted a small area of the planet.

All observations of Saturn were made at the 72-inch Perkins telescope of the Ohio State and Ohio Wesleyan Universities at the Lowell Observatory.

The optical system consists of a conventional two-channel polarimeter containing a Wollaston prism. A scanning head is mounted in the focal plane of the telescope and the photomultipliers in the polarimeter are followed by two pulse-counting systems and two multichannel analyzers.

In operation, a small aperture is scanned once a second across the image of the planet being studied. The output of each multiplier is recorded nearly simultaneously on a multichannel analyzer where the data are integrated.

As in the case of Jupiter, intensity scans were successively made with the analyzer oriented at position angles of 0°, 45°, 90° and 135°. The total number of counts at 82 positions of the scanner usually corresponded to 40 or 60 passes of a circular focal plane aperture (0.6 or 1.2 sec in diameter) across the planet. The length of scan was usually 19 or 38 sec.

Saturn was observed on four nights in mid-October 1968 when it was close to opposition, and again on the two last nights of December 1968 and on the first two nights of January 1969. The equatorial and polar diameters were 20.0 and 18.0, respectively, for the first series of measures and 17.8 and 15.8 for the second.

In making the reductions, the counts along the scan across the face of the planet were divided, using the Stokes parameters, into about ten mean points. Therefore, under perfect seeing conditions, a typical mean point would correspond to an area on Saturn's disk 1.6–2.0 sec in length and either 0.6 or 1.2 sec wide.

As was the case with observations of Jupiter, some scattered light could be detected beyond the edge of the disk. This light often showed strong polarization, and since the number of pulse counts due to scattered light was relatively small, these data have lower accuracy.

2. Measures in the ultraviolet

An intensity scan along the equatorial zone of Saturn is shown in Fig. 1. Of particular interest is the dark band in this zone, which shows very little evidence of limb darkening. When several E-W intensity scans were

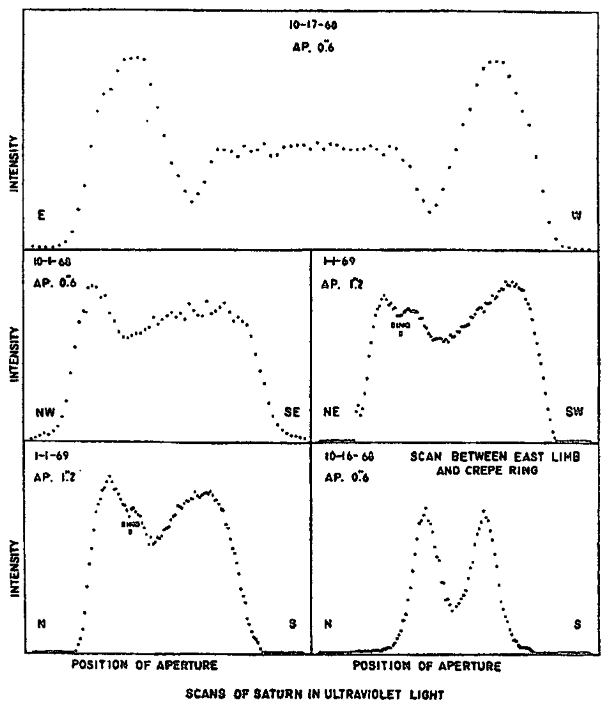

FIG. 1. Intensity scans of Saturn obtained with filter UG1 (λ3760). The direction of each scan, the focal plane aperture and the dates of observation are indicated.

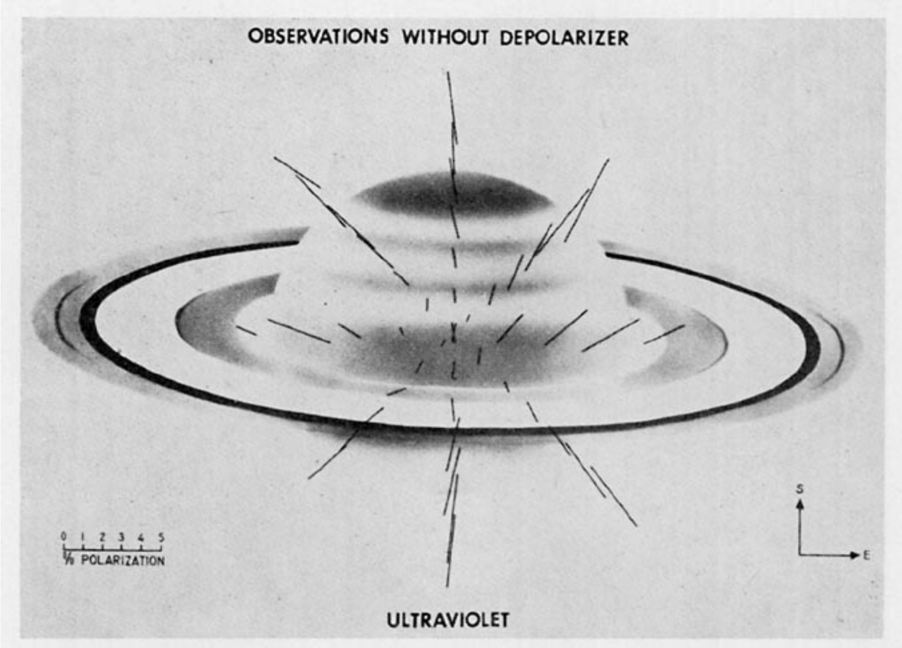

FIG. 2. Mean polarization vectors obtained in three different directions. The E-W vectors were computed by averaging the Stokes parameters found on six nights. Data from four, three, and four nights are included in the N-S, NW-SE and NE-SW vectors, respectively. The drawing, made by Jay Inge, is based on a UV photograph of Saturn obtained at the Lunar and Planetary Laboratory in October 1968. He increased the angle of rings from 12° to 15° in order to show the divisions more clearly.

compared with the UV photograph (see Fig. 2), it was apparent that a guiding or centering error of only 1 sec could increase the observed intensity parallel to the equatorial zone by a factor of 2. Since the band was not visible to the observer, the results obtained from the E-W scans in this direction were especially sensitive to guiding or centering errors.

The enhanced brightness of the disk where the rings pass in front of it can be seen in the intensity diagram of the N-S scan also shown in Fig. 1.

The polarization vectors found in the UV are presented in Fig. 2. These vectors were derived by combining the Stokes parameters observed on several nights.

On four nights, observations with a depolarizer were

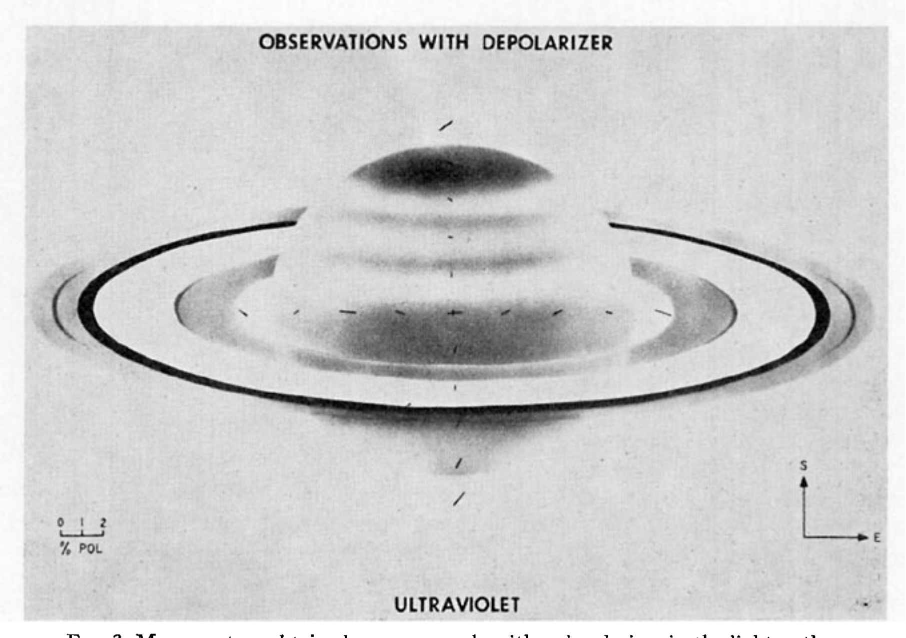

FIG. 3. Mean vectors obtained as scans made with a depolarizer in the light path. Data obtained on four nights are included in both the N-S and E-W vectors.

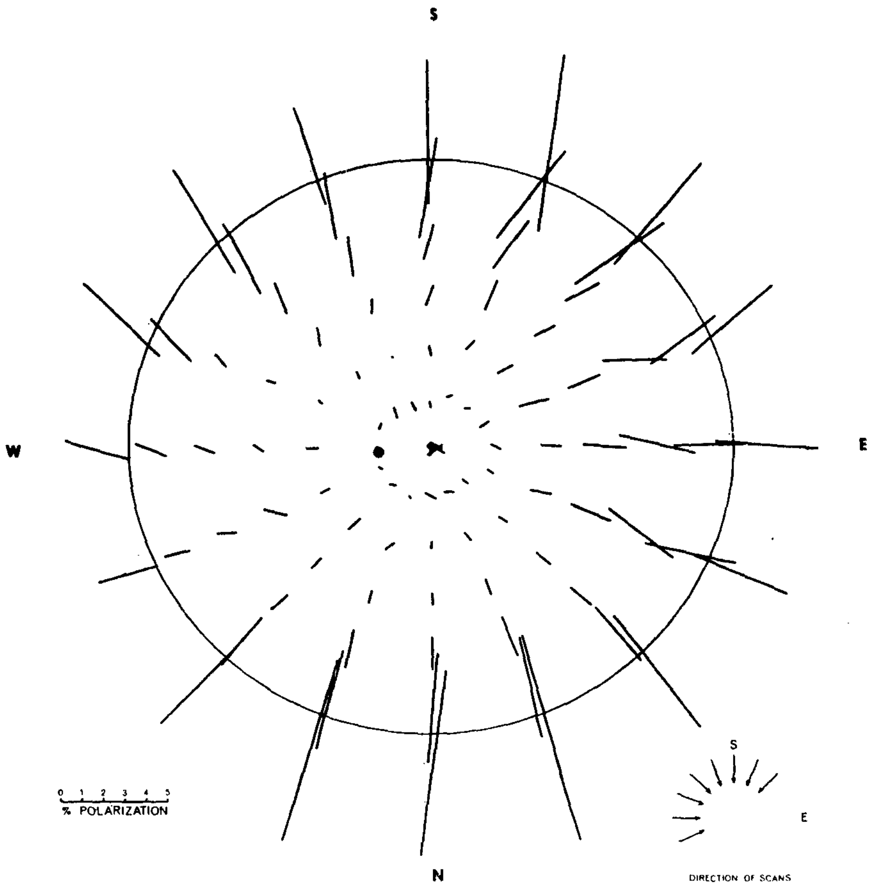

FIG. 4. Polarization measures of Jupiter obtained in UV light, near λ3760, on 24 April 1968. The subsolar point is indicated by the small circle and the optical boundary of the planet is designated by the large ellipse.

also made on the N-S and E-W scans. The observed instrumental polarization shown in Fig. 3 is not much larger than would be expected from the statistical scatter of the number of counts involved.

Some UV observations of Jupiter which were previously published are reproduced in Fig. 4. A comparison of Figs. 2 and 4 indicates that except in the equatorial zone, the vectors show similar radial patterns.

Near the center of the Jupiter disk the polarization is very small. For Saturn, it seems to decrease more slowly from the limbs toward the center of the disk. Because of Saturn's smaller disk, this effect could be made more conspicuous by polarized light scattered from the limb areas.

For both planets, the polarization at the poles is definitely greater than at the east and west limbs. Polarization measures of Jupiter made in a number of spectral regions by Gehrels *et al.* (1969) show interesting temporal changes at the poles.

The outstanding difference which may be resolved by further observation is the direction of the vectors on the E-W scans of Saturn. This may be somehow related to light from the rings or due to systematic effects because, as explained above, the scans were made very close to a junction between a light and a dark zone. If either of these possible sources of systematic error was caused by unpolarized light, the observations with the depolarizer (Fig. 3) should show the same systematic trend. This is not the case.

The polarization observed across that portion of the ring which occults the disk is not very much different from what would be expected if the polarization of the two hemispheres of Saturn were the same. This is not surprising because the ring was nearly edge-on and didn't add much light of its own (see Fig. 1).

3. Measures in the visual

Lyot (1929) carried out visual measures of polarization of Saturn in the years 1922–1927. He studied regions near the center, where he found a small phase effect, and at the poles and also in zones and bands. Because of the low altitude of the planet at meridian passage over Meudon, and because of its small size and low surface brightness, he reported that his observations were of less accuracy than those he made of Jupiter. He found a predominant vibration perpendicular to the limb only near the poles, with values of ~3% and reported numerous very small temporal changes in polarization, there and elsewhere. He did not observe a general radial pattern.

Our measures of Saturn in the visual region indicate radial polarization, even in the E-W direction. Since the central band in the visual is bright and broader than in the UV, the observations along the equator were not as sensitive to guiding errors.

The visual observations are not as numerous as those made in the UV and will be published in more detail after more extensive data have been obtained.

4. Conclusion

The general picture resulting from this series of observations of Saturn is one in which multiple scattering by a dense atmosphere is indicated. Our observations suggest that the particles and scattering mechanism in the atmosphere of Saturn resemble those of Jupiter. However, before one can draw a definite conclusion, the reality of the anomaly found in the E-W scans must be further investigated.

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