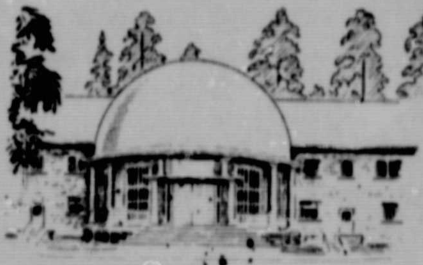

LOWELL OBSERVATORY
BULLETIN NO. 146

VOL. VII — SEPTEMBER 4, 1968, FLAGSTAFF, ARIZONA — NO. 9

PRELIMINARY OBSERVATIONS OF THE JOVIAN 6190A METHANE BAND

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NGR-03-003-001

ABSTRACT

Photoelectric spectrum scans of small areas of the Jovian surface were made during the spring of 1968. A computer program computed the equivalent width of the 6190A methane band by comparing the scans to similar scans of the moon. The resulting mean error of a single determination of the equivalent width is 2 percent. The average equivalent width at the center of the disk was 16.9A. However, a day to day variation of up to 2A in the equivalent width was found. The equivalent width also increased with distance from the center of the disk.

INTRODUCTION

As emphasized by Hess (1953) knowledge of the distribution of methane across the disk of Jupiter can lead to a determination of the amount of methane above the reflecting cloud layer which can in turn be used to estimate a variation in height of the cloud layer. Early investigation of this problem (e.g., Elvey and Fairley, 1932) showed only a small variation across the disk of Jupiter. To check these results, Hess (1953) determined the equivalent width of the 6190A band of methane at several points on the disc of Jupiter. He concluded that the equivalent width decreased toward the poles which he attributed to an increase in the height of the visible cloud layer. Urey (1959) quotes Dollfus as not being able to confirm Hess' results. In addition, Urey remarks upon the difficulty of sustaining the temperature changes required by Hess' theory. Consequently, it seemed appropriate to reexamine this question with modern instrumentation which should yield higher accuracies in the determination of the equivalent width.

OBSERVATIONAL TECHNIQUE

The Lowell spectrum scanner was used on the 72-inch Perkins reflector of the Ohio State and Ohio Wesleyan Observatories at the Lowell Observatory to obtain spectral scans of Jupiter and the moon. A system of D.C. amplification and voltage-to-frequency conversion was used to digitize the signal which was then recorded in a 1000-channel multiscaler. The contents of the multiscaler were punched on paper tape for subsequent reduction by a computer.

The spectral scans covered the region from 6000A to 6500A with a resolution of 9A. The photomultiplier was an EMR 541-R with a tetra-alkali cathode and was kept at a constant temperature of −20°C by means of a thermoelectric cooler. The scan speed was 180A/min. and the integration time was 0.2 seconds during which the exit slit was moved 1.25A. Each scan took approximately 3 minutes to complete.

A round focal-plane aperture 5.8 seconds of arc in diameter was used for all the observations. Positioning and guiding were accomplished by visually centering the image of Jupiter and using an offset guider to maintain the centering during the course of a scan. One of the outer satellites of Jupiter was used as a guide star. The image was recentered after each scan to correct for motion of the satellite relative to the planet. The guiding and positioning accuracy is estimated to be 1.5 seconds of arc (max. error) at the center of the disk and somewhat poorer at other positions.

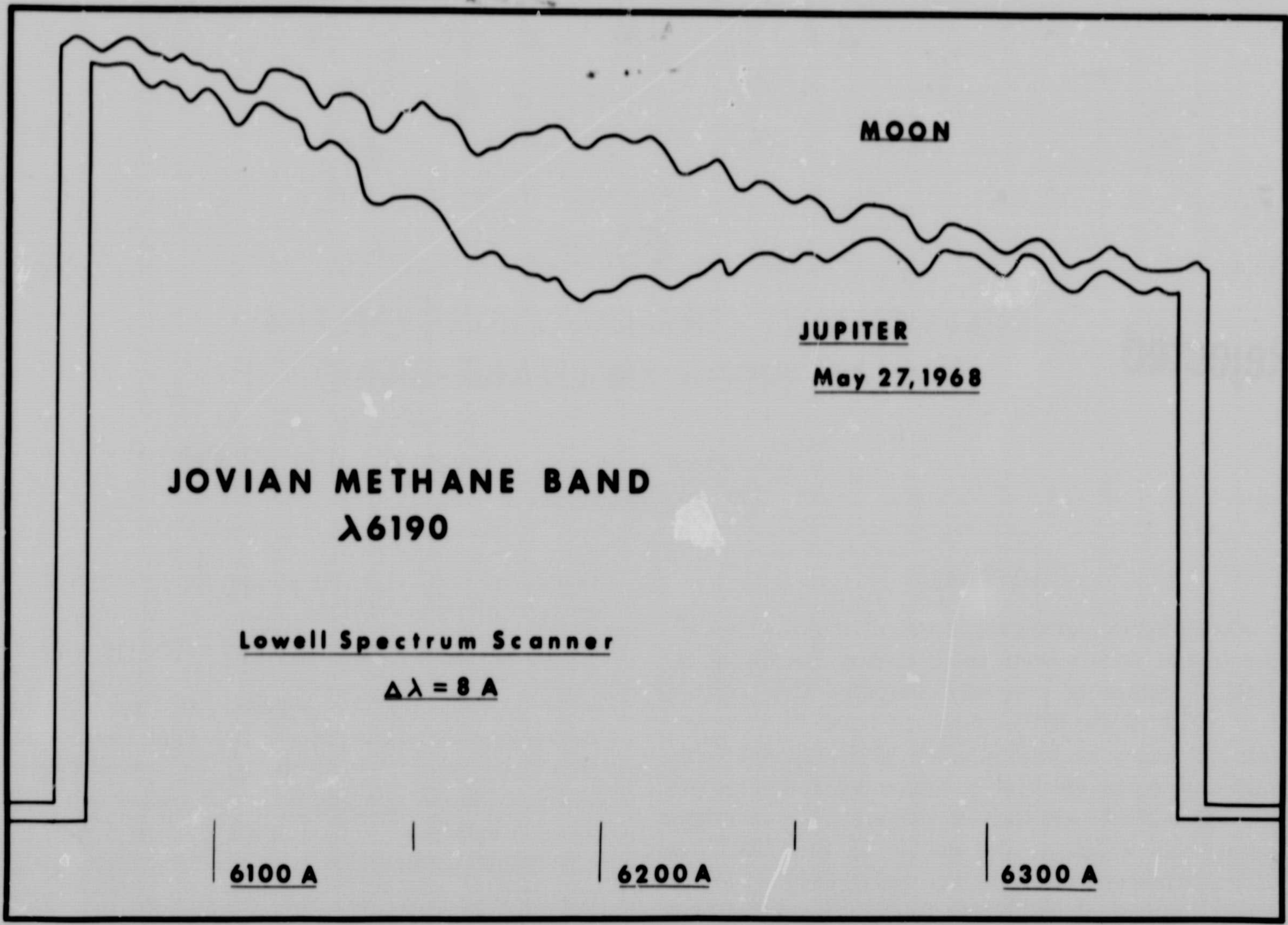

Fig. 1. A spectrum scan of the center of the Jovian disk shown normalized to the standard moon scan. The regions λλ6045-6120A and λλ6285-6360A were used to determine normalizing factors.

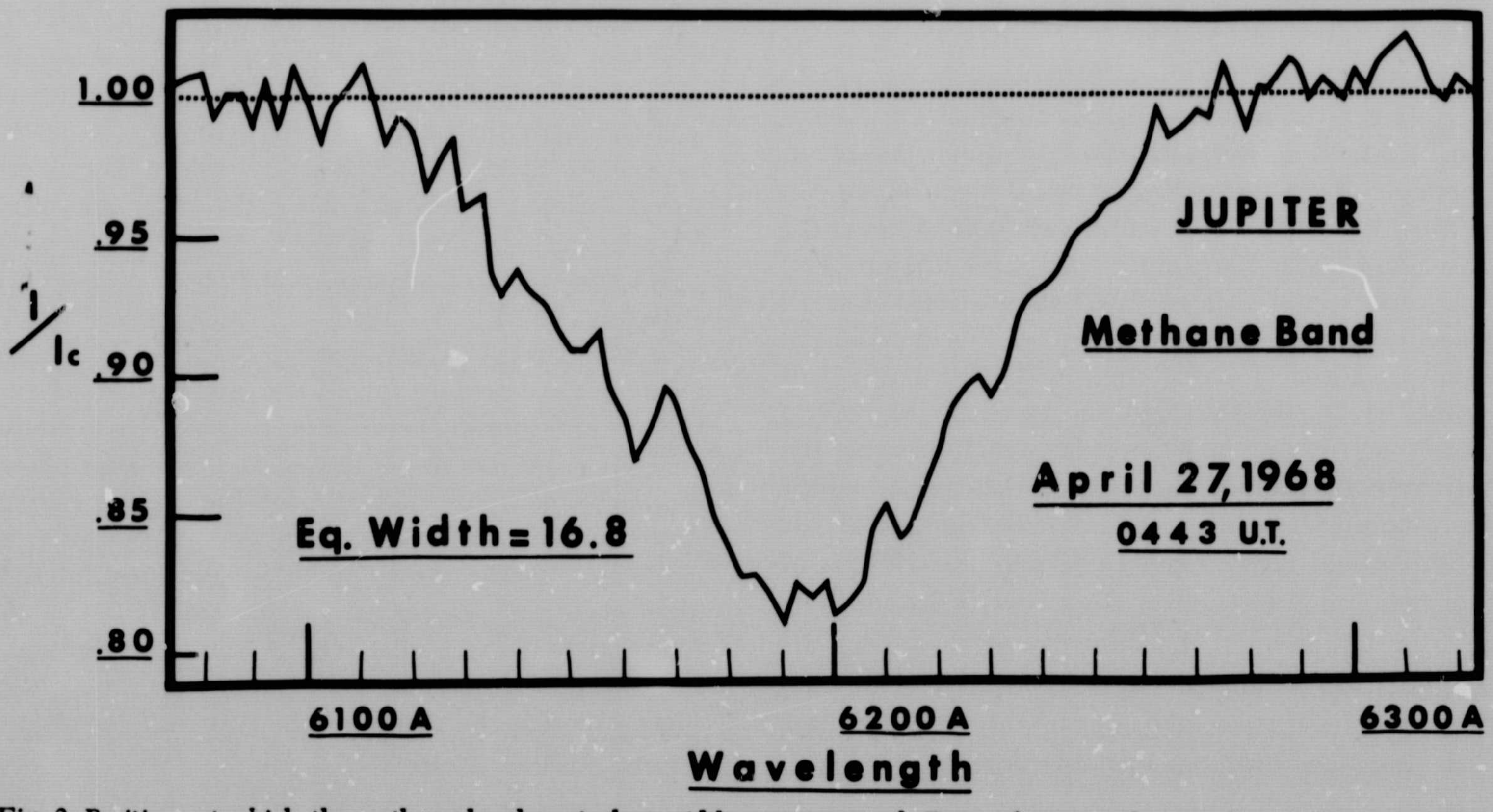

Fig. 2. Positions at which the methane band equivalent width was measured. Ratio of measured equivalent widths to equivalent width at center of disk is given for each position.

TABLE I

DATE 1968	U.T.	LCM System I	LCM System II	Equiv. Width	Position
Apr. 27	0432	100°	166°	16.7A	Centered
	0440	105	171	16.5	6″8 south
	0446	109	174	16.4	6″8 south
	0459	117	182	16.9	Centered
	0513	125	190	18.9	11″3 east (in sky)
Apr. 28	0418	249	307	17.7	Centered
Apr. 29	0430	056	106	15.7	Centered
	0442	062	112	14.9	9″2 north
	0506	077	127	16.2	Centered
	0515	082	132	17.2	9″8 north
	0521	086	136	18.9	12″6 north
May 7	0253	178	167	17.2	Centered
May 27	0329	115	312	16.6	Centered
	0337	119	316	17.4	Centered
Jun. 2	0408	005	156	17.6	Centered
	0417	010	161	17.1	Centered

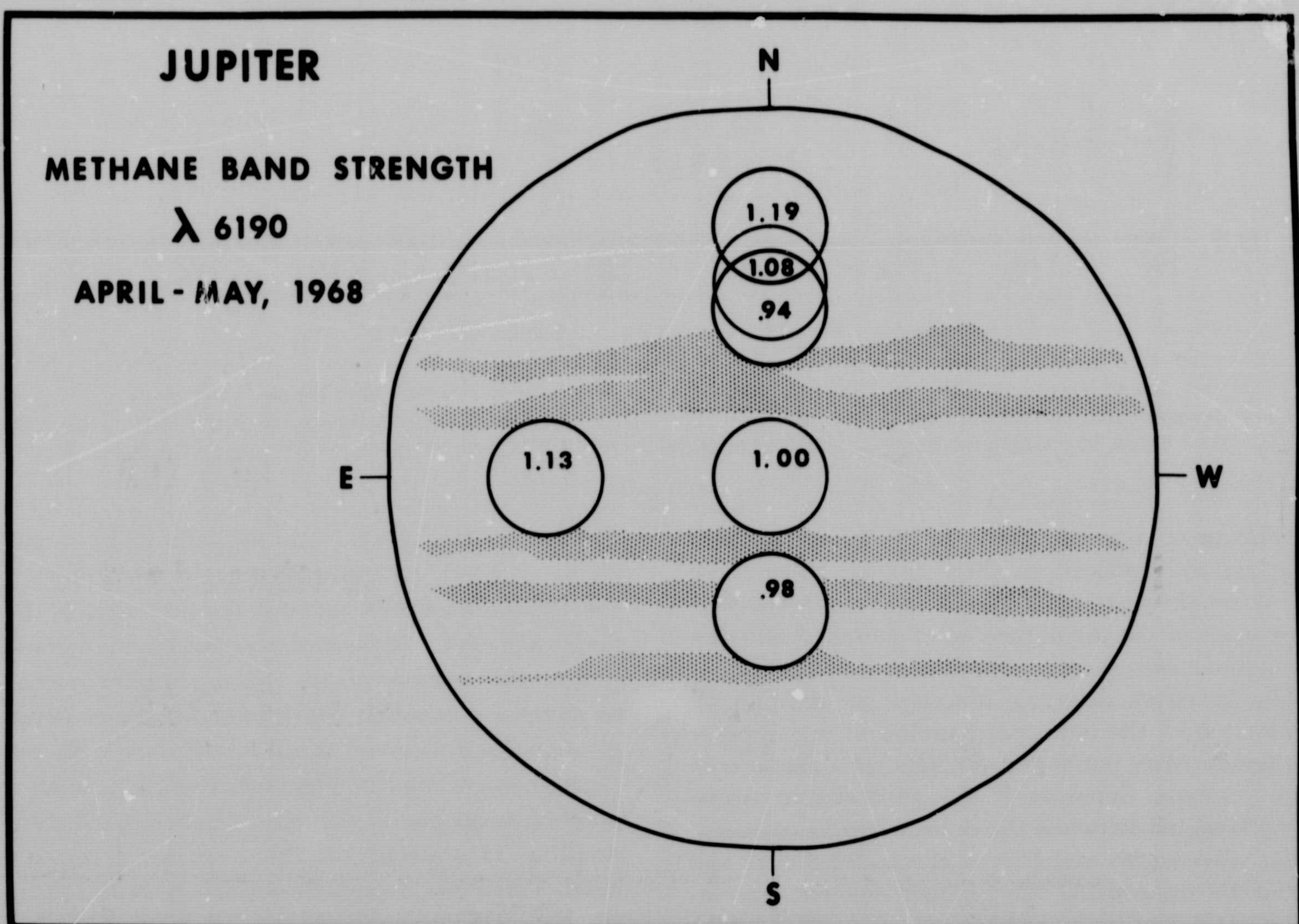

Fig. 3. Methane band profile. Solar continuum has been subtracted out.

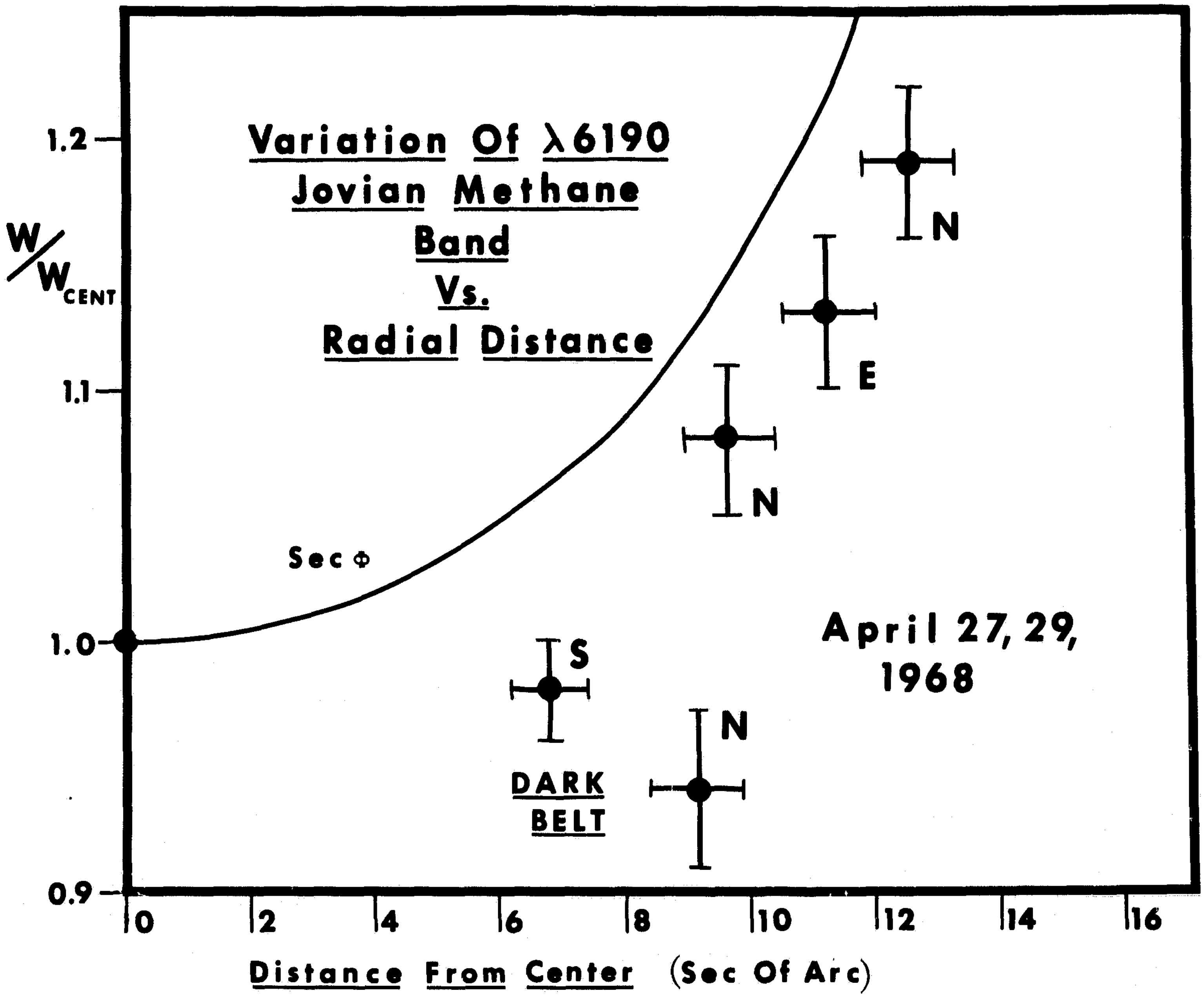

Fig. 4. Variation of equivalent width of λ6190A methane band as a function of distance from the sub-earth point. Each point represents one measurement except at a radius of 6.8 sec. which is an average of two measurements. Error bars denote estimated mean errors. The solid line denotes a variation proportional to the secant of the angle from the sub-earth point.

Similar scans were obtained of the moon at varying zenith distances on three nights. Since there were no systematic differences between the different scans of the moon they were averaged into one standard moon scan.

In an effort to be as objective as possible all reduction of the data was handled by a computer program. After reading in the data for a single scan the program determined the approximate wavelength match between the Jovian and lunar scans. The wavelength match was checked by trial and error by maximizing the product moment correlation coefficient in the wavelength range 6285-6360A which contains several strong solar features. As a result the scans were matched in wavelength with an accuracy of ±0.6A. The Jovian scan was normalized to the moon scan at both ends of the methane band λλ6045-6120A and λλ6285-6360A. Finally, the total area between the two scans in the range λλ6120-6285A was determined and normalized to the average of the two continuum regions to give the equivalent width of the methane band. A normalized scan of Jupiter is shown with the average moon scan in Figure 1. Figure 2 shows a point-by-point plot of differences between the scans resulting in a profile of the methane absorption band. There was no significant change in the shape of the methane band during the course of the observations although two scans had been obviously distorted by the occurrence of clouds during the observations and were discarded.

OBSERVATIONAL RESULTS

Table I lists the observational results including date and time of beginning of scan, local central meridian of Jupiter in System I, and II, the derived equivalent width and the position of the aperture on the disk of Jupiter. The average mean error as determined from pairs of observations made on the same day is less than 0.25A or 2 percent of the equivalent width. Using this estimate of the error the observed differences in the strength of the methane band at the center of the disk are certainly real (formal confidence level greater than 0.97). However, there are not nearly enough data to determine whether the variation is simply secular or is a function of LCM and surface activity on the planet or both.

Observations were obtained at several different points on the disk on the nights of April 27 and 29. Figure 3 depicts the positions of the aperture with relation to the major dark bands on the disk of Jupiter. Also included are the ratios of the equivalent widths with respect to the value at the center of the disk. The photograph from which the sketch of the surface features was made was taken on April 28 at 0401 U.T. at New Mexico State University. There is a definite trend for the band strength to increase with increasing distance from the center of the disk. Figure 4 is a plot of the band strength as a function of the radial distance from the center of the disk. The solid line gives the secant of the angle from the sub-earth point. This plot does not take into account any possible variations due to the differential rotation of Jupiter. Nevertheless, the increase with radial distance is very marked. The values marked "dark band" refer to observations in which a portion of the aperture covered a dark belt. On the basis of only two observations the evidence points to a weakening of the methane band in the dark belts. Further observations will be needed to substantiate this.

In comparing this work with that of Hess (1953) who found a marginally significant decrease in band strength with radial distance it should be noted that the total observed variation recorded here is contained within Hess' quoted mean error.

CONCLUSION

This study has shown that the $6\nu 3$ band of methane at 6190A on Jupiter undergoes variations which are statistically significant. It can be stated tentatively that the band strength increases toward the limb of the planet and also shows variations either with time or position on the planet or both. Finally, the methane band appears slightly weaker over the dark belts than over the bright areas.

ACKNOWLEDGMENTS

It is a pleasure to acknowledge the able assistance of Norman C. Crowfoot, who wrote the computer programs and assisted in the reductions of the observations. The question of the methane band variability was originally called to my attention by Stuart E. Jones of the Lowell Observatory Planetary Research Center staff. Computer time and some of the observational equipment used in this study were furnished by NASA Grant NsG-451. Thanks are also due to Bradford Smith of New Mexico State University for so quickly providing the necessary photographs of Jupiter.

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