ASTRONOMISCHE NACHRICHTEN.

N^o 3354.

Band 140.

18.

Observations of the Spots and Markings on the Planet Jupiter

made at the Dearborn Observatory of Northwestern University, Evanston, U. S. A.

by *G. W. Hough*, Director.

[With a plate.]

During the past twenty-five years, the physical phenomena seen on the disk of the planet Jupiter have been studied by many observers, with both large and small telescopes. And although a great mass of material has been collected yet but little progress has been made towards a definite knowledge regarding the constitution of the surface of the planet. For the proper interpretation of the changes taking place we need continuous and accurate determinations of longitude, latitude and magnitude of objects, extending over a long period of time.

Hitherto observations have been very largely devoted to motion in longitude, or rotation period. I am under the impression that the study of latitude variations will lead to quite as important results.

A sketch of the visible phenomena at a definite time is useful for showing the relative position of objects, but in addition precise numerical data is desirable. Drawings made at long intervals cannot well be compared until allowance is made for the displacement in latitude due to the elevation of the earth above the equator of the planet.

In *Astr. Nachr.* 3325 Mr. A. Stanley Williams has called attention to the use of photography for the study of planetary phenomena. From measures of Lick photographs of Jupiter, made in 1892-3, he concludes that position on the disk may be determined from the photograph as accurately as with the micrometer. This conclusion does not seem to be well established, for the residuals in longitude which he obtains indicate a probable error many times greater than is given by the photographic measures.

A photographic plate may be measured with any required degree of precision, but whether a planetary image of seventeen millimeters in diameter will furnish data of value to science is a very doubtful question.

Our study of the Jovian surface is limited to the equatorial and middle latitudes on account of the rapid foreshortening of the degrees of latitude in the polar regions. Spots or detached markings are rarely seen beyond forty degrees of Jovian latitude. On Nov. 10, 1893, however, I observed a white spot $T = 9^h 14^m 4$, distance from the apparent equator $-16''.85$ or 62.3 jovicentric latitude. Owing to bad weather the spot was not seen again. The parallel of seventy degrees lies at one second, and that of eighty degrees, at one quarter of a second of

arc from the limb of the planet and hence the polar regions are entirely beyond our reach.

My observations of Jupiter were begun in 1879 and have been continued annually except for the year 1888, when the telescope was dismantled. My aim has been to study Jovian phenomena by means of micrometrical measurement of size and position rather than from sketches or drawings. Rough sketches showing the salient features under examination, however, are frequently made to more clearly indicate the objects recorded.

The observations which follow were made with the $18\frac{1}{2}$ in. Refractor and a power of 400. The longitude, or time of passage over the central meridian of the disk, is determined by three measures of the distance of the object from each limb of the planet, and noting the time to the nearest tenth of a minute, at each bisection. The latitude is determined in the same manner by measuring from the north and south limbs respectively. For all micrometer measures, of whatever kind, which are referred to a luminous disk, it is essential to employ both limbs in order to eliminate the effect of irradiation, or what is of greater importance the enlargement of the disk due to bad definition.

T = time of passage over the central meridian of the luminous disk, not corrected for defective illumination. The time is that of the 90th meridian, or 6 hours slow of Greenwich M. T.

β = distance from the apparent equator of the disk. After applying the correction for the elevation of the earth above Jupiter's equator, the distance north or south of the equator is designated reduced latitude.

It seems to me wholly unnecessary to convert direct distance into jovicentric or jovigraphic latitude; since such latitude conveys no definite information regarding the place of a spot or marking on the disk, until it has been reconverted into seconds of arc.

The great red spot.

The great red spot which has been quite pale for a number of years appeared well defined in outline near the time of opposition. From Dec. 13th, 1894 to Febr. 23^d, 1895 it was sufficiently distinct for measures of length and breadth. On Jan. 16 the center of the spot was much

lighter than the edges, giving the ring-form, which was so prominent a feature in 1885.

The measures for longitude or, T , are comparatively rough, for the reason that the spot was often too indistinct to see any definite outline.

The first column is the date; second, days elapsed; third, time of passage over the central meridian; fourth, longitude in time from Marth's meridian II; fifth, length of the chord when on the middle of the disk; sixth, breadth; seventh, distance from the apparent equator.

The residuals in column 4 indicate a slight increase in the rotation period, but the observations are too discordant for a nice adjustment. For the 400 day interval, Dec. 20, 1893 to Jan. 24, 1895, the rotation period was $9^h 55^m 40^s.95$. This value depends upon normal places derived from five observations near each date. During the past five years the rotation period has not varied very much from Marth's Ephemeris, $R = 9^h 55^m 40^s.63$.

The mean of the residuals for 1894-95 makes the spot follow Marth's meridian II $4^m.6$ time. The shape and size of the great red spot appears to have undergone but little change since 1879. The length during recent years appears to have been about 1" shorter than when it was most conspicuous. This result, however, may possibly be due to the difficulty in tracing the outline owing to the faintness of the object. From 1879 to 1895 the red spot has varied in latitude to the amount of $1^{\circ}.7$ arc. The extreme annual mean values for the reduced latitude were $-7^{\circ}.21$, April 10, 1886, 9 observations, and $-5^{\circ}.53$, Dec. 14, 1893, 8 observations. The motion in latitude during the past seventeen years, would seem to indicate that this object is the most stable of any marking on the surface of the planet.

The great red spot.

Date	Days	T	Long.	L	B	β
1894						
Sept. 26	0	$15^h 15^m.9$	$+ 1^m.1$	—	—	—
Oct. 10	14	$16 42.2$	$- 5.4$	—	—	$-6^{\circ}.12$
Dec. 3	68	$11 26.6$	$+ 9.1$	—	—	—
8	73	$10 31.2$	$+ 6.8$	—	—	$-7^{\circ}.06$
13	78	$9 42.6$	$+ 11.2$	$10^{\circ}.25$	—	-6.84
25	90	$9 39.5$	$+ 16.2$	—	—	-7.32
28	93	$6 56.8$	$+ 4.3$	—	—	—
1895						
Jan. 2	98	$6 1.9$	$+ 2.2$	12.48	—	-7.92
9	105	$6 53.5$	$+ 8.4$	10.76	$3^{\circ}.96$	-7.74
16	112	$7 32.6$	$+ 1.8$	11.79	—	-6.80
23	119	$8 22.2$	$+ 5.4$	—	—	—
26	122	$5 43.9$	$- 2.6$	—	—	-7.46
28	124	$7 25.3$	$+ 0.5$	—	—	-6.27
Febr. 2	129	$6 36.1$	$+ 3.1$	—	—	—
14	141	$6 34.5$	$+ 6.1$	—	—	-7.18
16	143	$8 12.6$	$+ 5.6$	—	—	-6.17
19	146	$5 38.8$	$+ 1.7$	—	—	-6.59
21	148	$7 20.7$	$+ 4.9$	—	—	-6.73
23	150	$9 7.3$	$+ 6.8$	10.29	3.53	-6.95

Date	Days	T	Long.	L	B	β
Febr. 26	153	$6^h 33^m.6$	$+8^m.9$	—	—	$6^{\circ}.22$
Mar. 5	160	$7 14.3$	$+1.8$	—	—	7.38
10	165	$6 27.5$	$+5.7$	—	—	—
19	174	$8 58.4$	$+9.4$	—	—	—
April 3	189	$6 17.3$	-0.7	—	—	6.82
10	196	$7 10.8$	$+3.9$	—	—	7.43

Mean day 120 = Jan. 24 1895.

Longitude $+4^m.6$ 25 obs.

Length $11^{\circ}.11$ 5 "

Breadth 3.74 2 "

Reduced latitude -6.28 18 "

Mean length 1879-87 $11^{\circ}.61$ or $37^{\circ}.2$.

Mean breadth " 3.87

Reduced mean latitude 1879-95 $-6^{\circ}.33$.

The Equatorial Belt.

The heavy belts, usually of a reddish color, lying between parallels of $+18^{\circ}$ and -18° is designated the Equatorial Belt. The north edge of this belt has maintained a sharp outline since 1879, with one exception. About Oct. 11th, 1882 the drift in latitude had carried it so far north that the belt became blended with B_3 and continued so until Febr. 12th, 1883, when it was again separate. During the opposition in 1894-95, the southern portion of the belt was at times mottled with a great number of small white spots. The belt was made up of two nearly equal bands separated by an open space. The outsides of the belt are generally sharply defined, but the inside is indefinite in outline. According the data which follows, the relative width of the different parts, were north part 3", open part 4".7 and south part 3".3. The north edge of the belt was practically stationary in latitude during the whole opposition, but the south edge shifted in south latitude about $0^{\circ}.6$ of arc. An inspection of the table of results shows that the south side of the belt was irregular in outline, the width varying slightly for different longitudes. The mean results for 14 years are as follows:

Reduced latitude, north edge of the Belt $+4^{\circ}.08$
 Inclination to the equator $+0^{\circ}.12$
 Mean width $9^{\circ}.21$
 or Reduced latitude, south edge -5.13

The first column is the date; second, longitude in time, Marth's meridian II; third, position angle of the north edge; fourth, comparison with Marth's ephemeris; fifth, distance from the apparent equator; sixth, width of the belt.

All quantities are reduced to mean distance.

The Equatorial Belt.

1894	Long.	P	O - E	β	W
Sept. 17	$+3^m.2$	$93^{\circ}.3$	$+0^{\circ}.5$	$+4^{\circ}.25$	$10^{\circ}.23$
26	$+3.0$	93.0	-0.3	$+4.89$	10.39
Oct. 30	$+7.4$	94.9	$+1.1$	$+4.14$	9.67

Date	Long.	<i>P</i>	O — E	β	<i>W</i>
1894					
Nov. 15	+3 ^m .5	94°3	+0°9	+4°54	10°86
21	+8.5	94.6	+1.4	—	8.44
Dec. 4	+2.3	—	—	—	10.27
7	+5.4	93.5	+1.1	+4.57	10.25
14	+4.8	93.2	+1.2	—	—
17	+5.2	92.6	+0.8	+4.03	10.94
21	+2.4	92.8	+1.2	—	—
25	+7.8	93.4	+2.1	—	—
29	+5.2	91.2	+0.1	—	9.54
1895					
Jan. 2	+0.1	92.1	+1.3	—	—
16	+8.6	92.0	+2.0	+4.56	9.99
19	+3.5	93.1	+3.2	+4.25	10.93
Febr. 14	+0.3	90.7	+1.6	—	—
15	+4.2	91.7	+2.6	+3.84	10.95
19	+1.5	90.0	+0.9	+4.45	10.23
Febr. 19	+3.2	—	—	—	11.28
22	+3.7	92.0	+2.9	—	—
23	+8.0	89.7	+0.6	+3.88	9.89
25	+7.5	89.1	0.0	—	—
26	+3.0	89.8	—0.7	+4.41	—
Mar. 4	+6.2	91.3	+2.1	+3.82	9.65
5	+0.5	—	—	—	10.55
6	+4.8	—	—	+4.43	10.88
11	+4.8	—	—	+4.04	10.60
16	+5.7	—	—	+4.10	10.88
20	+3.2	—	—	+4.19	11.24
25	+3.5	—	—	+4.86	11.21
26	+7.0	—	—	+5.37	10.97
April 2	+8.0	—	—	+4.64	11.14
9	+6.7	90.1	+0.7	+4.40	11.05

Mean +1°2 (23)

Mean Day	(83)	Reduc. Lat.	+5°06 (10)
"	" (180)	"	" +5.04 (11)
"	" (83)	Width	10.21 (13)
"	" (180)	"	10.78 (12)

Width.

Date	Long.	N. part	Open p.	S. part
1894				
Sept. 17	+3 ^m .2	3°41	—	3°97
Oct. 30	+7.4	—	3°54	—
Nov. 15	+3.5	—	4.08	3.68
Dec. 7	+5.4	—	5.33	—
1895				
Jan. 19	+3.5	3.50	4.20	3.40
Febr. 15	+4.2	—	4.60	—
23	+8.0	3.16	4.24	2.54
Mar. 6	+4.8	2.25	4.88	3.54
16	+5.7	—	5.44	—
25	+3.5	3.00	5.20	3.00
April 9	+6.7	2.67	5.55	2.96
Mean		3.00	4.71	3.30

Spots on the north edge of the Equatorial Belt.

During the opposition of 1890 five small black spots were observed, giving rotation periods 9^h 55^m 32^s.0 to 36^s.6. Two of these spots were observed again in 1891; rotation period 9^h 55^m 27^s.4. Vide: »Monthly Notices« April, 1892. In 1892 and 1893 the spots were not visible. During the past opposition six black spots were observed, some of which are possibly identical with the objects seen in 1890 to 1891, but the rotation periods vary too greatly to identify the objects with any degree of certainty. The spots appeared each year in precisely the same latitude, while the edge of the equatorial belt was displaced about 0°8 during the interval, as the following numbers will show:

Date	Reduced Latitude		
	Spots	N. edge Eq. Belt	Spots — Belt
1890	+4°62	+4°79	—0°17
1891	+4.67	+4.23	+0.44
1894	+4.65	+5.05	—0.40

Five well defined white spots were also observed near the north edge of the Equatorial belt. The following reduced latitudes were observed: *a*₀ +5°37 (4); *m* +4°57 (1); *n* +4°56 (1).

The rotation period corresponding to each spot has been computed and the observations compared with an ephemeris. All spots on the surface of the planet generally have a variable proper motion and observations extending over long periods can only be satisfied by making the rotation period a function of the time. I have not thought it worth the trouble to treat all the observations in this manner, but have done so for the spots *a* and *b*. In other cases for which a mean period would not suffice, I have divided the observations and employed separate rotation periods.

The following table gives the longitude in time of each spot at the first and last observation, referred to Marth's Meridian II, the interval in days, and the rotation period. For the spots *a* and *b* the quantity, *n*, represents the number of rotations which have elapsed since the date of the first observation.

For the white spot, *d*₀, the period covered by the observations is too short to be of value in determining rotation. In the determination of rotation period, the observations have been corrected for longitude of equinox, aberration time, annual parallax, and defective illumination. With the exception of the longitude of equinox, all the other corrections have been derived from Marth's Ephemerides.

Black spots on north edge Equatorial Belt.

Name	Longitude		Interval Days	Rotation
	Marth's First obs.	Mer. II Last obs.		
<i>a</i>	+3 ^h 15 ^m	+0 ^h 39 ^m	205	9 ^h 55 ^m 22 ^s .8 Mean
<i>b</i>	+3 47	+2 23	198	17.2 + n × 0°.0213
				30.0 Mean
				28.0 + n × 0°.0079
<i>c</i>	+4 1	+3 39	106	36.6
<i>d</i>	+6 46	+6 19	161	38.1
<i>e</i>	+7 27	+7 47	60	49.1
<i>f</i>	+9 25	+8 59	159	35.3
				33.2

White spots on north edge Equatorial Belt.

Name	Longitude		Interval Days	Rotation
	Marth's First obs.	Mer. II Last obs.		
a_0	+1 ^h 1 ^m	+0 ^h 3 ^m	76	9 ^h 55 ^m 23 ^s .2
c_0	+3 29	+3 22	67	38.1
d_0	+6 37	+6 35	19	[38.4]
m	+8 5	+7 38	132	36.0
				44.2
n	+8 34	+7 50	76	25.4

Black spot a .

$$R = 9^h 55^m 22^s.8 \text{ (Eph}_1\text{)}$$

$$= 9 \ 55 \ 17.2 + n \times 0^s.0213 \text{ (Eph}_2\text{)}.$$

Date	Days	T	$O - E_1$	$O - E_2$
1894				
Sept. 17	0	16 ^h 4 ^m 5	+12 ^m 0	+0 ^m 9
Oct. 24	37	11 0.0	- 0.2	- 2.3
Dec. 4	78	9 15.0	- 0.7	- 0.4
21	95	8 4.1	+ 1.6	+ 2.7
28	102	8 41.6	- 0.5	+ 0.4
1895				
Jan. 2	107	7 46.1	- 0.1	+ 1.3
7	112	6 52.4	+ 2.8	+ 4.2
9	114	8 27.3	+ 1.1	+ 2.3
24	129	5 35.1	- 3.4	- 2.5
Febr. 14	150	7 41.6	- 2.1	- 2.5
16	152	9 20.2	- 0.7	- 1.3
19	155	6 48.1	- 0.6	- 1.5
21	157	8 26.5	+ 0.7	- 0.4
23	159	9 59.4	- 3.0	+ 2.0
26	162	7 32.9	+ 2.5	- 0.2
Mar. 5	169	8 10.2	- 3.1	- 6.6
10	174	7 20.9	+ 1.0	- 2.1
19	183	9 44.0	+ 3.3	- 0.9
22	186	7 16.9	+ 7.7	+ 2.9
April 3	198	7 6.8	+ 8.0	+ 0.9
10	205	7 54.5	+ 12.1	+ 3.7

Black spot β .

$$R = 9^h 55^m 30^s.0 \text{ (Eph}_1\text{)}$$

$$= 9 \ 55 \ 28.0 + n \times 0^s.0079 \text{ (Eph}_2\text{)}.$$

Date	Days	T	$O - E_1$	$O - E_2$
1894				
Sept. 17	0	16 ^h 37 ^m 0	+3 ^m 8	+0 ^m 8
24	7	17 18.2	+1.3	- 0.9
Nov. 15	59	9 52.5	- 7.3	- 6.8
27	71	9 39.0	+ 1.8	+ 2.8
Dec. 4	78	10 22.2	+ 3.2	+ 4.3
21	95	9 9.8	- 0.8	- 0.3
31	105	7 24.5	+ 3.8	+ 5.1
1895				
Jan. 9	114	9 37.9	- 2.3	- 1.1
17	122	6 12.1	- 1.8	- 0.7
19	124	7 49.7	- 1.5	- 0.4
24	129	6 53.5	- 3.7	- 2.5

Date	Days	T	$O - E_1$	$O - E_2$
1895				
Jan. 31	136	7 ^h 38 ^m 3	- 2 ^m 1	- 1 ^m 1
Febr. 14	150	9 5.2	- 3.0	- 2.3
15	151	4 59.2	- 0.1	+ 0.4
19	155	8 8.4	- 6.2	- 5.6
22	158	5 43.5	- 0.2	+ 0.3
26	162	8 58.2	- 1.1	- 0.8
Mar. 13	177	6 23.2	+ 2.7	+ 1.4
20	184	7 7.8	+ 2.0	+ 0.5
25	189	6 16.4	+ 3.2	+ 3.1
27	191	7 52.6	+ 1.3	+ 1.2
April 3	198	8 40.5	+ 3.5	+ 2.8

Black spot c .

$$R = 9^h 55^m 36^s.6.$$

Date	Days	T	$O - E$
1894			
Dec. 14	0	9 ^h 23 ^m 9	+3 ^m 8
17	3	6 48.2	- 1.5
29	15	6 38.8	- 0.9
1895			
Jan. 3	20	5 45.7	0.0
15	32	5 37.1	+ 1.1
17	34	7 14.0	- 1.0
19	36	8 51.3	- 1.5
24	41	8 1.6	+ 1.8
Febr. 15	63	6 6.2	- 1.8
22	70	6 52.9	- 0.4
Mar. 6	82	6 50.3	+ 2.2
11	87	5 59.9	+ 3.5
20	96	8 24.3	+ 2.0
25	101	7 29.1	- 1.9
30	106	6 39.0	- 0.9

Black spot d .

$$R = 9^h 55^m 38^s.1.$$

Date	Days	T	$O - E$
1894			
Oct. 30	0	10 ^h 9 ^m 0	+11 ^m 3
Dec. 3	34	7 55.2	+ 1.7
5	36	9 30.8	- 0.6
7	38	11 8.2	- 0.7
17	48	9 22.4	+ 0.2
29	60	9 10.5	- 2.5
1895			
Jan. 1	63	6 41.8	- 0.2
Febr. 13	106	7 4.9	- 1.5
15	108	8 44.3	- 0.3
18	111	6 15.2	+ 1.1
25	118	7 1.4	+ 0.1
Mar. 2	123	6 14.4	+ 4.5
4	125	7 47.0	- 1.5
11	132	8 31.2	- 4.5
16	137	7 43.0	- 1.7
21	142	6 54.2	- 1.4
April 2	154	6 48.4	- 1.5
9	161	7 38.4	- 0.5

Date	Days	T	O - E
------	------	-----	-------

Black spot f .

1) $R = 9^h 55^m 35^s.3$.

1894			
Nov. 4	0	[12 ^h 0 ^m]	[+6 ^m 3]*
21	17	10 50.2	+0.1
Dec. 3	29	10 38.2	-1.1
8	34	9 43.8	-1.5
13	39	8 51.5	+0.5
17	43	12 6.2	0.0

* estimated.

2) $R = 9^h 55^m 33^s.2$.

1895			
Febr. 16	104	7 29.5	+2.1
18	106	9 8.8	-0.7
23	111	8 14.0	+1.4
Mar. 19	135	7 57.9	-3.1
26	142	8 41.1	-3.9
April 10	157	6 7.1	-2.2
12	159	7 49.3	+2.0

Black spot e .

$R = 9^h 55^m 49^s.1$.

1895			
Febr. 18	0	7 16.7	0.0
25	7	8 4.8	-1.9
April 19	60	7 26.5	0.0

White spot a_0 .

$R = 9^h 55^m 23^s.2$.

1895			
Jan. 2	0	7 0.6	-2.8
9	7	7 43.6	-0.2
Febr. 14	43	7 2.5	+0.7
16	45	8 44.6	+5.7
19	48	6 5.1	-2.8
21	50	7 49.4	+5.5
23	52	9 20.6	-0.7
26	55	6 53.5	+3.9
Mar. 5	62	7 30.2	-2.3
19	76	8 51.7	-7.4

White spot c_0 .

$R = 9^h 55^m 38^s.1$.

1895			
Jan. 17	0	6 50.9	-2.5
19	2	8 32.8	+1.4
Febr. 15	29	5 52.7	+4.9
19	33	9 4.0	-0.8
Mar. 11	53	5 45.0	+5.8
20	62	7 59.0	-6.4
25	67	7 12.2	-2.5

Date	Days	T	O - E
------	------	-----	-------

White spot d_0 .

$R = 9^h 55^m 38^s.4$.

1895			
Mar. 2	0	6 ^h 23 ^m 5	+2 ^m 7
4	2	7 58.8	-0.6
11	9	8 44.6	-2.3
16	14	7 53.4	-2.4
21	19	7 7.5	+2.7

White spot m .

1) $R = 9^h 55^m 36^s.0$.

1894			
Nov. 21	0	9 34.5	+4.7
23	2	11 2.4	-5.2
Dec. 3	12	9 20.4	+1.1
17	26	10 44.8	-2.3
25	34	7 23.2	+2.4
1895			
Jan. 16	56	5 24.3	-0.5

2) $R = 9^h 55^m 44^s.2$.

1895			
Febr. 18	89	7 22.4	0.0
23	94	6 29.8	-2.1
25	96	8 8.6	-2.4
Mar. 2	101	7 22.4	+1.3
7	106	6 32.8	+2.3
9	108	8 11.1	+1.3
16	115	9 0.8	+1.9
21	120	8 11.7	+2.5
26	125	7 15.5	-3.9
April 2	132	8 8.7	-0.5

White spot n .

$R = 9^h 55^m 25^s.4$.

1895			
Jan. 16	0	6 8.8	-2.9
Febr. 16	31	6 30.8	+2.1
18	33	8 4.9	-1.2
23	38	7 11.9	0.0
25	40	8 51.7	+2.2
Mar. 2	45	7 58.8	+2.9
7	50	7 4.7	+3.2
16	59	9 19.8	-3.4
21	64	8 26.6	-2.9
April 2	76	8 20.8	+0.3

Elliptical white spots on B_6 .

During every opposition since 1880 elliptical white spots have appeared on a belt south of the great red spot. White spots are also seen in latitude $-10''$ to $-12''$, but are usually too faint to measure except under favorable atmospheric conditions. These spots give approximately the same rotation period as the great red spot.

The belts on the disk are numbered beginning at the north limb.

B_1 = south edge of the shading, which in 1894-95 extended to the limb. Reduced latitude $+11^{\circ}18'$ (2).

B_2 reduced latitude $+10^{\circ}08'$ (2).

B_3 reduced latitude $+7^{\circ}45'$ (9), width $0^{\circ}61'$ (2).

B_6 reduced latitude $-8^{\circ}90'$ (2), width $1^{\circ}21'$ (2).

B_7 = north edge of shading, extending to south limb. Reduced latitude $-12^{\circ}00'$ (1).

The map of Jupiter for March 1, 1895 has been drawn to show the relative position of the belts and spots which have been observed. The longitude is in time from Marth's Meridian II and the latitude is distance from the apparent equator; all quantities being reduced to mean distance. No attempt has been made to show in detail

the structure of the great equatorial belt, but the relative size and position of all objects are based on micrometrical measurements.

The sketch of the planet for Febr. 15th, 1895 shows the third satellite in transit as a black spot. Near the middle of the disk the satellite appeared round and black, and at the first glance was mistaken for a shadow. When at a distance of $2^{\circ}4'$ of arc from the limb of the planet, the color was less marked and at $2''$ from the limb the satellite appeared smaller and was barely visible. When the distance from the limb was only $1^{\circ}7'$ the satellite appeared as a white disk. After emersion, when the distance from the limb of the planet was $0^{\circ}4'$, the outline was sharply defined and there was an absence of glow around the disk as though the satellite was immersed in a medium which absorbed some of its light.

The apparent latitude at transit was $-11^{\circ}49'$.

Dearborn Observatory, Evanston, Ill., 1896 February.

G. W. Hough.

Micrometrical Measures of the Annular Nebula of Lyra (M. 57)

made with the 36 inch Equatorial of the Lick Observatory by *E. E. Barnard.*

The following measures of the Ring Nebula, M. 57 were made at different times with the great telescope.

The magnifying power employed was 520. With this power the nebula was a very fine object and its different details were brought out with remarkable distinctness.

The aperture of the ring was filled with a feebler nebulosity which was estimated to be nearly midway in brightness between the brightness of the ring and the darkness of the adjacent sky. This aperture was not concentric with the outer edges of the ring, but was more nearly circular. The ends of the ring were thicker than the sides. The following end of the ring had a slightly greater extension which was less bright than the ring itself. Both the following and preceding ends of the ring were fainter and less definite. The light of the entire nebula was of a milky color. The central star was usually seen but at no time it was specially conspicuous.

The maximum brightness lies in the northern part of the ring.

Position Angles of the major axis.

	PA.
1892.502	65 ^o 1
1892.521	67.2
1892.540	68.7
1893.676	63.3
1894.158	64.4
1894.194	64.3
1895.152	67.0
1895.385	65.6
1895.440	63.3
Mean	1893.952 65.43

Outer major diameter.

1892.540	80 ^o 72
1893.676	82.15
1895.152	78.83
1895.385	81.28
1895.440	81.46
Mean	1894.439 80.89

Inner major axis.

1892.521	35 ^o 21
1892.540	36.88
1893.676	38.02
1895.152	37.23
1895.440	35.27
Mean	1893.866 36.52

Outer minor axis.

1892.521	56 ^o 80
1892.540	59.34
1893.676	60.08
1895.152	60.14
1895.385	57.14
1895.440	59.36
1894.119	58.81

Inner minor axis.

1892.521	28 ^o 56
1892.540	28.53
1893.676	31.02
1895.152	28.18
1895.440	30.53
1893.866	29.36