THE

ASTRONOMICAL JOURNAL.

No. 275.

VOL. XII. BOSTON, 1892 OCTOBER 4. NO. 11.

DISCOVERY AND OBSERVATIONS OF A FIFTH SATELLITE TO *JUPITER*,

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Since July 1 of this year, I have had the use of the 36-inch refractor on one night each week. Previous to this I had no regular use of the instrument, and the observations made with it were of specified objects, the time being limited to the object. Among other things that I have devoted the instrument to on my nights, was a search for new objects. Several of the nights have been bad, and have more or less limited the investigations.

Nothing of special importance was encountered until the night of September 9, when, in carefully examining the immediate region of the planet *Jupiter*, I detected an exceedingly small star close to the planet and near the 3d satellite. I at once suspected this to be a new satellite. I at once measured the distance and position-angle of the object with reference to satellite III. I then tried to get measures referred to *Jupiter*, but found that one of the wires had got broken out and the other loosened. Before anything further could be done the object disappeared in the glare about *Jupiter*. Though I was positive the object was a new satellite, I had only the one set of measures, which was hardly proof enough for announcement.

I replaced the wires the next morning. The next night with the great telescope being Professor Schaeberle's, he very kindly gave the instrument up to me, and I had the pleasure of verifying the discovery, and secured a good set of measures at elongation. In these observations, and those of the succeeding night, only distances from the following limb of *Jupiter* could be measured. These were observed with the wires set perpendicular to the belts. The planet was thrown outside the field, the satellite bisected, and then the limb brought in and bisected also. This method would not permit any measures from the poles of the planet for latitude. On the 12th, I inserted a strip of mica, carefully smoked, in front of the field-lens, for occulting the planet. This served admirably, permitting the satellite and planet to be both seen at once, and measures from the polar limbs could be made with great ease. The observations of the satellite from the 12th were all thus made.

To avoid any personal equation, I have on each night measured the diameters of the planet, for use in reducing the observations to the center of *Jupiter*. Since the 12th, these have been measured through the smoked mica, so as to avoid introducing any error from the reduced brightness of the planet. The diameters were measured by the method of double distances.

Just what the magnitude of the satellite is, it is at present quite impossible to tell. Taking into consideration its position, however, in the glare of *Jupiter*, it would, perhaps, not be fainter than the thirteenth magnitude. It will only be possible to settle this question with any certainty by waiting until some small star of the same magnitude is seen close to *Jupiter*, and then after determining its magnitude when away from the planet. In general the satellite has been faint — much more difficult than the satellites of *Mars*. On the 13th inst., however, when the air was very clear, it was quite easy.

It is scarcely probable that this satellite will be seen with anything less than 26 inches, and only with that under first-class conditions.

I give here the observations that I have so far obtained, and defer any suggestions as to a name until a later paper. It certainly should not disturb the present harmony existing in the Roman numerals already applied to the satellites. It is so wholly different from any of the other moons in physical aspect, that it ought, in a sense, to be considered independent of them, and simply be called, say, the fifth satellite, with a suitable mythological name.

It will be seen that, on three of the dates of observation, the east elongation is well covered in the measures.

Plotting the observations at elongation, the following values of the distance were obtained:

				From *Jupiter's* center.
Sept. 10	(apparent)	61.″04	$\log R = 7.08267$	112250 miles
12	"	61.55	" 7.08452	112750 miles
14	"	61.60	" 7.08324	112400 miles

From these the following periods result, using the well-known formula:

$$P = p\sqrt{\frac{m}{M}\frac{R^3}{r^3}}$$

m being the mass of the earth, M that of *Jupiter*, and r and p the distance and period of our moon.

		h	m
Sept. 10 the observations give period	=	11	47.6
12 " " " "	=	11	52.3
14 " " " "	=	11	49.0
Mean		11	49.63

The observations are all in the Standard Pacific time, (8 hours slow of Greenwich).

The value of the micrometer-screw used in these observations is 9″.904. No correction has been applied for refraction.

After the 11th inst., the micrometer was removed before or after the observations on each night. It was also removed on the morning of the 10th to replace the wires. This will account for the apparent changes of parallel.

1892 *September* 9.

Measures referred to Satellite III.

Direct Distance.

h m s	r	″
12 13 33	28.670	28.58
12 14 58	28.649	28.79

For Position-Angle.

h m s	°	P. A. °
12 19 31	125.0	295.8
12 21 28	125.1	295.9
12 31 40	129.7	300.5
12 33 43	131.1	301.9

Parallel = 279°.2

Direct Distance.

h m s	r	″
12 41 23	29.241	22.92
12 43 48	29.274	22.60
12 47 33	29.341	21.93

Coincidence of wires, 31r.556.

1892 *September* 10.

Measured equatorial diameter of *Jupiter* (by double distance), 48″.93.

The half-value of this has been added to the measures from the limb, to reduce the observation to the center of *Jupiter*.

For position-angle of belts:

Circle-reading = 255°.8 (3 obs.) Position-angle = 67°.1.

Parallel = 278°.7 (2 obs.)

Coincidence of micrometer-wires, 29r.003.

New wires put in this morning.

Standard Pacific Time	Micrometer readings	Dist. from f. limb	Distance from center
h m s	r	″	″
11 45 20	26.250	27.25	51.72
11 47 30	26.183	27.91	52.37
11 49 0	26.097	28.77	53.25
11 52 0	26.073	29.00	53.46
11 52 25	25.065	29.08	53.54
11 5 25	25.715	32.55	57.01
12 7 20	25.631	33.38	57.84
12 14 28	25.686	32.84	57.30
12 20 30	25.419	35.48	59.94
12 23 40	25.494	34.74	59.20
12 26 10	25.413	35.54	60.00
12 32 30	25.408	35.60	60.06
12 35 30	25.384	35.83	60.29
12 39 35	25.395	35.73	60.19
12 41 30	25.330	36.37	60.83
12 45 10	25.366	36.01	60.47
12 48 40	25.345	36.22	60.68
12 50 30	25.198	37.68	62.14 *
12 54 10	25.319	36.48	60.94
13 1 40	25.284	36.83	61.29
13 4 0	25.370	35.97	60.43
13 6 25	25.475	34.93	59.39
13 9 23	25.427	35.41	59.87
13 11 5	25.421	35.47	59.93
13 19 20	25.502	34.67	59.13
13 22 13	25.534	34.35	58.81
13 23 47	25.657	33.13	57.59
13 25 45	25.660	33.10	57.56
13 27 35	25.707	32.64	57.10
13 29 45	25.699	32.72	57.18
13 31 5	25.712	32.59	57.05
13 34 22	25.891	30.81	55.27
13 35 57	25.903	30.70	55.16
13 37 33	25.857	31.15	55.61
13 38 43	25.896	30.76	55.22
13 40 25	25.920	30.53	54.99
13 42 37	25.950	30.23	54.69
13 46 1	26.099	28.76	53.22
13 47 40	26.031	29.43	53.89
13 51 35	26.234	27.42	51.88
13 54 51	26.275	27.01	51.47
13 57 41	26.434	25.34	49.80
13 59 7	26.451	25.27	49.73
14 1 5	26.490	24.88	49.34
14 5 0	26.676	23.04	47.50
14 7 54	26.831	21.51	45.97
14 11 0	26.885	20.97	45.42

*Reject.

1892 *September* 11.

For position-angle belts:

Circle-reading = 255°.4. Position-angle = 66°.7.

Parallel = 278°.7 (2 obs.)

Coincidence of wires = 28r.998.

Measured equatorial diameter of *Jupiter*, 49″.11.

Standard Pacific Time	Micrometer readings	Dist. from f. limb	Distance from center
h m s	r	″	″
12 27 2	25.359	36.03	60.58
12 35 12	25.346	36.16	60.71
12 38 17	25.265	36.96	61.51
12 41 35	25.230	37.31	61.86
12 44 6	25.262	36.99	61.54
12 46 37	25.385	35.78	60.33
12 48 14	25.286	36.76	61.31
12 52 32	25.429	35.25	59.80
12 54 17	25.373	35.89	60.44
12 56 4	25.393	35.70	60.25
13 0 7	25.432	35.22	59.77
13 1 28	25.447	35.16	59.71
13 3 2	25.477	34.86	59.41
13 4 30	25.515	34.49	59.04
13 7 49	25.595	33.70	58.25
13 9 24	25.551	33.14	57.69
13 10 57	25.547	34.17	58.72
13 13 43	25.535	34.29	58.84
13 15 44	25.540	34.24	58.79
13 17 42	25.555	34.09	58.64

1892 *September* 12.

Observed polar diameter, 46″.01.

The half-value of this has been used in deducing the apparent Jovicentric latitudes.

Measured equatorial diameter of *Jupiter*, 48″.97.

Position-angle of the belts:

Circle-reading = 255°.4 (5 obs.) Position-angle = 66°.7

Parallel = 278°.7

Coincidence of wires = 29ʳ.000.

Standard Pacific Time	Circle readings	Dist. from f. limb	Distance from center
h m s	r	″	″
12 3 1	32.509	34.75	59.23
12 4 56	32.395	33.62	58.10
12 6 20	32.393	33.60	57.08
12 7 27	32.504	34.70	59.18
12 9 22	32.562	35.18	59.66
12 11 0	32.612	35.77	60.25
12 12 44	32.568	35.24	59.72
12 13 53	32.629	35.93	60.41
12 16 41	32.625	35.89	60.37
12 17 56	32.723	36.86	61.34
12 19 46	32.550	35.15	59.63
12 20 46	32.641	36.05	60.53
12 22 8	32.639	36.03	60.51
12 23 12	32.730	36.93	61.41
12 24 3	32.685	36.49	60.97
12 25 7	32.694	36.58	61.06
12 26 31	32.740	37.03	61.51
12 28 51	32.687	36.51	60.99
12 30 16	32.718	36.82	61.30
12 31 40	32.747	37.10	61.58
12 32 46	32.750	37.13	61.61
12 34 23	32.752	37.15	61.63
12 36 11	32.683	36.47	60.95
12 37 50	32.783	37.46	61.94

Standard Pacific Time	Circle readings	Dist. from f. limb	Distance from center
h m s	r	″	″
12 39 16	32.725	36.88	61.36
12 40 53	32.769	37.32	61.80
12 42 31	32.731	36.94	61.42
12 43 44	32.773	37.36	61.84
12 45 19	32.660	36.24	60.72
12 48 33	32.707	36.71	61.19
12 49 48	32.730	36.04	61.42
12 51 4	32.647	36.11	60.59
12 52 44	32.642	36.06	60.54
12 54 18	32.660	36.24	60.72
12 56 1	32.659	36.23	60.71
12 58 23	32.583	35.48	59.96
13 2 1	32.525	34.90	59.38
13 3 43	32.529	35.04	59.52
13 4 56	32.605	35.70	60.18
13 6 6	32.480	34.46	58.94
13 7 11	32.506	34.72	59.52
13 9 6	32.542	35.07	59.55
13 10 29	32.412	33.79	58.27
13 11 56	32.404	33.71	58.19
13 13 21	32.348	33.15	57.63
13 14 57	32.363	33.30	57.78
13 17 27	32.303	32.71	57.19
13 20 6	32.281	32.49	56.97

Stand. Pac. Time	Circle read'g		4β
	From North Pole.		
h m s	r	″	″
11 43 31	26.775	22.03	+0.97
11 46 48	26.765	22.13	+0.87
11 49 28	26.773	22.05	+0.95
11 50 58	31.262	22.40	+0.60
	From South Pole.		
11 53 16	26.595	23.81	+0.81
11 54 23	26.634	23.43	+0.43
11 55 33	26.620	23.57	+0.57
11 56 28	26.574	24.01	+1.01
	From North Pole.		
13 31 3	31.554	25.29	—2.29
13 32 21	31.619	25.93	—2.93
13 33 26	31.533	25.08	—3.08
13 34 31	31.579	25.54	—3.54
13 35 46	31.506	24.81	—1.81
13 37 56	31.657	26.31	—3.31
13 39 26	31.514	24.89	—1.89
	From South Pole.		
13 41 48	26.910	20.73	—2.27
13 43 31	26.969	20.11	—2.89
13 44 41	26.931	20.49	—2.51
13 45 12	26.931	20.49	—2.51
13 45 36	26.899	20.80	—2.20
13 46 4	26.883	20.95	—2.05
13 46 32	26.908	20.71	—2.29
13 47 11	26.960	20.20	—2.80
13 48 12	26.943	20.37	—2.63
13 48 49	26.918	20.62	—2.38
13 49 47	26.920	20.60	—2.40
13 51 22	26.919	20.61	—2.39
13 54 36	26.895	20.84	—2.16

1892 *September* 13.

For position-angle of belts:

Circle-reading = 257°.(1 obs.) Position-angle = 67°.4.
Parallel = 279°.8.

Measured polar diameter, 46″.10.
Coincidence of wires, = 28ʳ.995.

1892 *September* 13.

From South Pole.

Stand. Pac. Time h m s	Circle-read'g r	″	4β ″
12 9 38	26.637	23.35	+0.30
12 10 19	26.625	23.47	+0.42
12 12 31	26.609	23.63	+0.58
12 18 34	26.633	23.39	+0.34
12 20 7	26.634	23.38	+0.33

From North Pole.

12 23 22	31.307	22.89	+0.16
12 26 17	31.321	23.03	+0.02
12 29 8	31.479	24.60	—1.55*
12 31 12	31.356	23.38	—0.33
12 35 17	31.394	23.75	—0.70
12 36 48	31.297	22.79	+0.26

* Wind shaking telescope badly. Reject.

From South Pole.

12 53 32	26.780	21.93	—1.12
12 54 2	26.707	22.66	—0.39
12 55 9	26.745	22.28	—0.77
12 55 37	26.779	21.94	—1.11
12 56 40	26.721	22.52	—0.53
12 57 24	26.661	23.11	+0.06

From North Pole.

13 2 6	31.324	23.06	—0.01
13 3 17	31.412	23.93	—0.83
13 4 17	31.474	24.55	—1.50
13 4 51	31.399	23.80	—0.75
13 6 0	31.425	24.06	—1.01
13 7 15	31.308	22.90	+0.16

Very high wind. Telescope shaking. No measures of distance possible.

1892 *September* 14.

Position-angle of belts:

Circle-reading = 256°.7 (3 obs.) Position-angle = 67°.0.
Parallel = 279°.7 (3 obs.)

Measured polar diameter, 45″.95.
Measured equatorial diameter, 49″.18.
Coincidence of wires = 29ʳ.007.

Standard Pacific Time h m s	Circle readings r	Dist. from f. limb ″	Distance from center ″
11 48 28	25.638	33.36	57.95
11 50 5	25.589	33.85	58.44
11 53 0	25.565	34.08	58.67
11 54 2	25.561	34.12	58.71
11 55 45	25.449	35.23	59.82
11 57 16	25.422	35.50	60.09
12 0 3	25.460	35.12	59.71
12 2 36	25.391	35.81	60.40
12 3 30	25.420	35.52	60.11
12 4 30	25.384	35.87	60.46
12 6 55	25.331	36.40	60.99
12 8 5	25.294	36.77	61.36
12 10 10	25.339	36.32	60.91
12 12 0	25.361	36.10	60.69
12 14 5	25.318	36.53	61.12
12 15 22	25.308	36.63	61.22
12 16 20	25.293	36.78	61.37
12 17 27	25.299	36.72	61.31
12 18 48	25.269	37.01	61.60
12 19 52	25.209	37.61	62.20
12 20 45	25.305	36.66	61.25
12 21 37	25.285	36.86	61.45
12 23 12	25.261	37.09	61.68
12 24 8	25.253	37.17	61.76
12 25 15	25.269	37.01	61.60
12 26 25	25.313	36.58	61.17
12 27 35	25.282	36.88	61.47
12 28 30	25.222	37.48	62.07
12 29 25	25.295	36.76	61.35
12 30 25	25.329	36.42	61.01
12 31 25	25.282	36.88	61.47
12 32 35	25.275	36.95	61.54
12 36 15	25.240	37.30	61.89
12 39 25	25.395	35.77	60.36
12 40 25	25.273	36.97	61.56
12 41 37	25.343	36.28	60.87
12 44 15	25.468	35.04	59.63
12 45 45	25.380	35.91	60.50
12 47 12	25.459	35.15	59.74
12 48 25	25.418	35.54	60.13
12 49 28	25.439	35.24	59.83
12 50 20	25.426	35.46	60.05
12 51 50	25.390	35.82	60.41
12 52 45	25.426	35.46	60.05
12 54 5	25.519	34.54	59.13
12 54 55	25.487	34.86	59.45
12 56 15	25.558	34.15	58.74
12 56 50	25.531	34.42	59.01
13 0 40	25.624	33.50	58.09
13 1 45	25.571	34.02	58.61

From North Pole.

Stand. Pac. Time h m s	Circle-read'g r	″	4β ″
11 1 30	31.155	21.27	+1.70
11 3 37	31.139	21.11	+1.86
11 4 45	31.145	21.17	+1.80
11 6 17	31.094	20.67	+2.30
11 7 6	31.108	20.80	+2.17

From South Pole.

Stand. Pac. Time	Circle-read'g		$\frac{1}{4}\beta$
h m s	r	″	″
11 8 18	26.379	26.02	+3.05
11 9 12	26.481	25.01	+2.04
11 10 25	26.453	25.25	+2.28
11 11 25	26.475	25.07	+2.10
11 13 50	26.479	25.03	+2.06
	From North Pole.		
13 16 45	31.471	24.40	—1.43
13 18 18	31.483	24.52	—1.55
13 19 20	31.475	24.44	—1.47
13 20 15	31.523	24.91	—1.94
13 21 10	31.465	24.34	—1.37
	From South Pole.		
13 22 45	26.850	21.36	—1.61
13 23 42	26.790	21.89	—1.08
13 24 30	26.830	21.56	—1.41
13 25 30	26.890	20.96	—2.01
13 26 12	26.824	21.62	—1.35
	From North Pole.		
13 38 20	31.492	24.61	—1.64
13 39 20	31.536	25.04	—2.07
13 40 20	31.529	24.97	—2.00
13 41 40	31.529	24.97	—2.00
13 42 32	31.533	25.01	—2.04
	From South Pole.		
13 44 20	26.883	21.03	—1.94
13 45 25	26.895	20.91	—2.10
13 46 15	26.949	20.38	—2.59
13 47 5	26.884	21.02	—1.95
13 47 55	26.832	21.54	—1.43
	From North Pole.		
13 59 50	31.583	25.51	—2.54
14 0 50	31.641	26.08	—3.11
14 2 7	31.545	25.13	—2.16
	From South Pole.		
14 3 7	26.912	20.76	—2.21
14 4 2	26.895	20.91	—2.06
14 4 50	26.940	20.47	—2.50

1892 *September* 16.

Sky thick and the satellite extremely difficult throughout the observations.

Mt. Hamilton, 1892 *September* 17.

From North Pole.

Stand. Pac. Time	Circle read'g		$\frac{1}{4}\beta$
h m s	r	″	″
11 16 35	31.192	21.65	+1.63
11 18 17	31.159	21.32	+1.96
11 19 57	31.101	20 74	+2.54
11 21 20	31.156	21.29	+1.99
	From South Pole.		
11 25 57	26.450	25.31	+2.03
11 27 42	26.568	24.14	+0.86
11 29 27	26.620	23.23	—0.05*
11 32 17	26.535	24.37	+1.09
11 35 55	26.564	24.47	+1.19

* Reject.

Coincidence of wires = 29ʳ.006.

In all the measures from the polar limbs, the wires were carefully adjusted parallel to the belts of *Jupiter* and the $\frac{1}{4}\beta$'s are simply the difference between the polar measures and the measured polar semi-diameters.

In the equatorial distances, the wires were carefully placed perpendicular to the belts (by the position-circle), and the final distances from the center are the measured distances from the *following* limb plus the measured equatorial semi-diameter.

Standard Pacific Time	Circle reading	Dist. from f. limb	Dist. from center
h m s	r	″	″
11 49 32	25.473	34.98	59.97
11 53 12	25.370	36.00	60.99
11 55 37	25.479	34.92	59.91
11 56 47	25.410	35.61	60.60
12 7 2	25.255	37.14	62.13
12 9 17	25.326	36.44	61.43
12 11 37	25.280	36.89	61.87
12 14 24	25.292	36.78	61.77
12 16 0	25.268	37.01	62.00
12 17 37	25.221	37.48	62.47
12 20 29	25.175	37.93	62.92
12 28 33	25.240	37.29	62.28

Satellite lost here in the thickening sky.

The latitude-measures of the satellite show that its orbit lies in the plane of *Jupiter's* equator, and consequently that the satellite is a very old member of *Jupiter's* family, since it would doubtless take ages for the orbit to be so adjusted.

OCCULTATION OF *MARS*,

By E. FRISBY.

I observed the first and second contacts of the occultation of *Mars* on Sept. 3. The moon was too low for the third and fourth contacts, being obscured by a tree near the horizon.

	1st Contact	2d Contact
Washington M.T.	$13^h\ 10^m\ 1^s.1$	$13^h\ 20^m\ 53^s.6$