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DEFINITIVE ORBIT OF COMET 1819 II,

By HENRY A. PECK.

This comet appeared suddenly about the beginning of July, emerging from the rays of the sun a few days after passing perihelion. A controversy arose early in the comet's history as to the validity of the observations of certain astronomers who claimed to have seen the comet in transit across the solar disc. In discussing this question, HIND computed an orbit from observations by GAUSS, NICOLAI and STRUVE, and suggests the possibility that the orbit may be other than a parabola. The first recorded measurement of position was made at Milan, July 3. The comet was last seen by STRUVE and KNORR October 25, but so faint that it was impossible to use the micrometer. Up to the present time no one has collected and reduced the observations of this body, although for a considerable period it was an object of much interest in the scientific world. On account of the necessity of compressing the material within the limits of a single paper of moderate length, everything has been omitted that was not absolutely necessary to enable a future investigator to test the present work for systematic errors of computation.

With this object in view, the following skeleton of the ephemeris employed is appended for the dates of the normal places. The elements used as a basis for the discussion are essentially those of HIND, reduced to the epoch 1819.0. These elements of HIND may be found in *M.N.*, Vol. 36, and are as follows:

$$\begin{aligned} T &= 1819 \text{ June } 27.71547 \text{ G.M.T.} \\ \Omega &= 273^\circ 41' 32'' \\ i &= 80^\circ 44' 38'' \\ \omega &= 13^\circ 26' 14'' \\ \log q &= 9.533233 \end{aligned} \quad \left. \vphantom{\begin{aligned} \Omega \\ i \\ \omega \end{aligned}} \right\} 1819.0$$

EQUATORIAL COÖRDINATES.

$$\begin{aligned} x &= [9.237921] r \sin [35^\circ 17' 50.8'' + v] \\ y &= [9.996725] r \sin [260^\circ 42' 30.1'' + v] \\ z &= [9.996730] r \sin [349^\circ 50' 18.2'' + v] \end{aligned}$$

The positions of the sun were found with the assistance of NEWCOMB's "*Tables of the Sun*," as follows:

		True long. of ☉	log R	Lat. of ☉	Sid. Time
July	5	102° 33' 39.4"	0.0072117	-0.21	6 ^h 50 ^m 34.6 ^s
	11	108 16 45.6	71438	-0.08	7 14 14.0
	19	115 54 42.5	69549	+0.78	45 46.4
Aug.	27	123 33 21.1	66154	+0.30	8 17 18.9
	4	131 12 37.7	61409	-0.39	48 51.3
	16	142 43 37.2	52694	+0.69	9 36 10.0
Sept.	26	152 22 7.9	43516	-0.19	10 15 35.5
	14	170 48 16.6	22839	+0.54	11 30 30.1
	24	180 35 12.3	0.0010744	-0.53	12 9 55.6
Oct.	13	199 19 5.5	9.9987028	+0.29	13 24 50.1

From these data the following coördinates of the sun were computed, using NEWCOMB's values of the obliquity of the ecliptic. The rectangular coördinates are referred to the true equinox and equator. The equation of time is to be added to apparent time.

Equation of Time	X	Y	Z
July 5 + 4 ^m 0.5 ^s	-0.221120	+0.910340	+0.395166
11	318852	885462	384368
19	5 49.8	444042	838404
27	6 8.5	561234	776164
Aug. 4	5 48.7	668209	699911
16	4 8.0	805473	562310
26 + 1 47.2	894874	429709	186533
Sept. 14 - 4 18.4	0.992354	+0.147358	+0.063969
24	7 47.7	1.002424	-0.009416
Oct. 13 -13 33.1	-0.940880	-0.302551	-0.131335

For the reductions from the equinox and ecliptic of 1819.0 to that of the date of observation the following values of the independent star numbers were computed from BAUSCHINGER's *Tafeln zur Theoretischen Astronomie*. These dates, as well as the preceding, are with reference to Greenwich Mean Noon.

(61)

	f	G	$\log g$	H	$\log h$	i
July 5	+19.60	315 51	1.0755	168 26	1.3094	+1.76
11	20.62	317 2	0888	163 7	3076	2.55
19	21.94	318 24	1063	155 58	3044	3.55
27	23.20	319 31	1232	148 40	3003	4.51
Aug. 4	24.38	320 25	1391	141 12	2956	5.37
16	26.02	321 29	1608	129 41	2882	6.48
26	27.23	322 12	1763	119 41	2824	7.19
Sept. 14	29.29	323 30	2005	99 59	2748	8.03
24	30.30	324 17	2110	89 21	2737	8.14
Oct. 13	+32.26	326 14	1.2278	69 5	1.2782	+7.68

The positions of the comet as given by HIND's elements for the dates of the normal places are,

	α app.	δ app.	$\log r$	$\log \Delta$	Ab. time
July 5	6 ^h 58 ^m 5.25 ^s	+45 48 31.0	9.6037	9.9408	0.00504
11	7 20 40.94	50 19 43.8	7053	0.0267	614
19	43 20.70	51 50 40.5	8265	1117	747
27	8 0 22.20	47 25.0	9224	1718	858
Aug. 4	13 53.01	20 49.2	9.9987	2157	950
16	29 51.14	50 40 22.7	0.0890	2621	1057
26	40 11.75	19 55.6	1492	2879	1121
Sept. 14	53 14.66	29 40.9	2395	3158	1195
24	56 22.43	51 3 51.4	2785	3222	1213
Oct. 13	8 52 59.31	+53 6 16.6	0.3412	0.3242	0.01219

Only a comparatively small number of observations are given which include the designation of the stars upon which the comet position depends. The places of these stars have in general been found by a comparison of Lalande and Groombridge with the A.G. Harvard and Bonn Catalogs. No. 2 and No. 19 belong to the Fundamental

Catalog. No. 5 is discussed by PORTER in the Cincinnati observations. The epoch of Groombridge is so near the time of the comet's appearance, that I have often given it more weight than it might receive in connection with more modern observations. The positions as used are:

	α 1819.0	δ 1819.0		α 1819.0	δ 1819.0		α 1819.0	δ 1819.0
1	6 ^h 21 ^m 54.04 ^s	+44 41 10.0	11	7 ^h 15 ^m 15.89 ^s	+48 16 39.5	21	8 ^h 23 ^m 39.01 ^s	49 59 23.5
2	33 41.06	43 44 43.6	12	16 9.56	50 2 1.2	22	30 2.36	50 37 45.4
3	44 23.67	45 18 58.5	13	19 25.78	51 41 20.7	23	50 18.00	39 3.4
4	54 5.48	43 8 1.2	14	25 34.51	50 55 41.1	24	53 41.63	
5	7 2 22.28	47 32 55.3	15	30 19.32	51 0.0	25	42.64	19 26.7
6	3 40.29	48 46 21.1	16	32 23.59	50 26 53.6	26	57 14.68	50 33 24.9
7	11 35.24	41 0 34.2	17	39 31.57	51 45 22.2	27	59 16.37	51 10 11.8
8	12 16.40	48 53 22.7	18	44 25.15	51 49 17.3	28	9 10 8.14	50 18 24.0
9	13 1.80	49 33 28.3	19	54 47.57	52 1 1.2	29	9 20 53.92	+50 13 46.4
10	7 14 7.61	+43 36 22.8	20	7 55 27.80	+51 49 47.2			

The following is a complete list of the published observations of this comet so far as they have come to my notice:

Berlin. A series by BODE, extending through July, and published in *Von Zach*, Vol. II, and the *B.J.* for 1822. The first five observations were made on the two-foot Troughton Circle, the comet being observed differentially. The remaining observations were made with a ring micrometer, on the 3.5-foot Dolland telescope.

Bremen. A series of observations by OLBERS, made with a ring micrometer, from July 6 to Oct. 12. The observations for July are reduced from the Schur-Stichtenoth

edition of OLBERS's Works. The remainder are taken from the *B.J.* for 1823, and are of necessity mere copies, as no data are given for a new reduction.

Cracow. These observations are contained in the *B.J.* for 1822. No use has been made of them on account of their inaccuracy.

Dorpat. This series by STRUVE and his assistants is one of the most important in existence. The right-ascensions during July and August were observed in the meridian at lower culmination. The declinations for the same period are deduced from zenith observations made with a repeating circle. At first the absolute zenith distance of the

comet was measured. Later, on account of the failing light of the comet, the difference of its zenith distance from that of the Pole Star was observed. The September and October observations were made with the ring micrometer. The star for October 12 can not with certainty be identified. In the *B.J.* for 1823 OLBERS states that he and STRUVE used the same star, and then gives the position of the comet as deduced by STRUVE. This position is the one used. Otherwise the observations have been reduced from the originals in *Dorpat Observations*, Vol. II, using the clock corrections given by STRUVE in Vol. III. The declinations contain the parallax.

Florence. Two observations recorded by VON ZACH. No details are given, but they were evidently transits at lower culmination.

Genoa. A series of July observations given by VON ZACH. Neither the observer's name, nor any other particulars, have been given. No use has been made of the series on account of the inexactness of the observations.

Göttingen. The first observation is by VON ZACH. During the interval July 19-26, GAUSS observed on the Repsold Circle at lower culmination. After July 26, GAUSS observed the transits on the Reichenbach instrument, and HARDING secured the declination with the Repsold Circle. The observations are published by VON ZACH, and in the *B.J.* for 1822.

Greenwich. A series of observations by POND. The meridian observations are published in the *Greenwich Observations* for 1819. The remainder are given by VON ZACH and the *B.J.* for 1822.

Hamburg. A single observation by REPSOLD, of which no use has been made.

Kremsmünster. A series of July and August observations, made with a three-foot Dolland telescope supplied with a net. The right-ascensions have been used, but not the declinations. These latter are evidently affected by some systematic error. The observations are published in the *B.J.* for 1822.

Mannheim. Nine observations by NICOLAI, given by VON ZACH and the *B.J.* for 1822. Except the last two all were made in the meridian.

Milan. These observations have been completely revised, using the material furnished by VON ZACH. The observer was CARLINI, and the instrument was an equatorial sector. After the observations had been reduced, they were found to contain a residual that varied its sign according as the transit of the comet had been observed above or below that of the comparison-star. Fortunately the observations had been made on a few days with two stars, so that this error

could be computed and eliminated. An average inclination of the vertical thread of the instrument used by CARLINI, amounting to a quarter of a degree, seems to explain the discrepancies.

Munich. The observations were made by SOLDNER upon a variety of instruments. They are to be found in *Von Zach*, and the declinations are not of very great worth.

Padua. A long series of observations published anonymously in *Von Zach*.

Palermo. Another long series published by CACCIATORE in the *B.J.* for 1823.

Paris. Two series published in the *Connaissance des Temps* and the first volume of the *Paris Observations*. The first series consists of meridian observations between July 5 and August 15. The other series are extra meridian observations extending throughout the months of July and August.

Prag. The observations of HALLASCHKA have not been used on account of their inexactness. The observations of DAVID and BITTNER have been reduced from the *B.J.* for 1823. They were made with a seven-foot Dolland equatorial. No account has been taken of the declinations, and the temptation to exclude the right-ascensions was very strong.

Seeburg (Gotha). A series of July and August observations by LINDEMAN and ENCKE. In general they are made with a ring micrometer, though throughout July the observation was often repeated on the meridian instrument. The series is to be found in *Von Zach* and the *B.J.* for 1822.

Vienna. These observations are to be found in the *B.J.* for 1823. A portion of the observations were made with a Dolland telescope, in which the sight field was used as a ring micrometer. The remainder were made upon a transit instrument. No account has been taken of the declinations.

Viviers. According to the *Bulletin Astronomique* there are observations of this comet by FLAUGERGUES, extending from July 5 to September 2, which have never been published. They would, however, be of comparatively small importance, as this portion of the orbit is well covered.

Wilna. In the *B.J.* for 1823 a series by SNIADOCKI from July 6 to August 10 is recorded. No particulars are given, but the observations were probably made upon a meridian instrument.

In comparing the observations with the ephemeris, the times of observation have been corrected for aberration, and also reduced to Greenwich Mean Time.

Date	Place	α apparent	π	O—C	Wt.	δ apparent	π	O—C	Wt.	*
July		$^h\ m\ s$	$''$	$\Delta\alpha\ \cos\delta$		$^h\ m\ s$	$''$	$\Delta\delta$		
2.46258	Berlin	6 47 0.00	. .	+21.9	1	+41 56 0.0	+11.0	+23.7	1	Mer.
3.35638	Milan	51 1.41	+0.43	+38.3	0	43 28 26.9	9.3	- 7.9	3	7
3.36607	Padua	50 53.00	.41	-81.2	0	14 40.0	9.7	-14' 53".0	0	. .
3.37753	Milan	51 3.62	.43	+ 5.3	2	30 35.8	9.3	- 2.1	3	10
3.38125	Vienna	4.51	.24	- 1.5	1				. .	4
3.38220	Munich	5.00	.34	+ 2.2	3	31 0.0	10.0	7.2	1	. .
3.42581	Dorpat	17.53	. .	8.1	3	35 39.7	. . .	+11.2	2	Mer.
3.43431	Paris	20.10	.24	14.8	2	35 59.1	10.0	- 7.6	2	2
3.44897	Seeberg	23.20	+0.08	+ 4.6	2	37 40.0	10.6	+ 9.0	2	. .
3.47023	Seeberg	28.13	. .	- 4.0	2				. .	Mer.
3.47467	Göttingen	29.40	. .	3.7	3				. .	Mer.
3.47653	Mannheim	30.07	. .	1.1	3	40 0.0	10.6	- 8.1	1	Mer.
3.50003	Greenwich	35.60	. .	8.7	2	41 13.0	10.7	68.7	0	Mer.
3.56151	Paris	51 53.23	-0.27	+3.1	2	47 51.1	10.0	-19.8	2	3, 1
3.63174	Palermo	52 11.20	-0.68	- 7.5	2	55 14.0	7.6	+28.3	2	. .
4.34319	Padua	55 24.13	+0.48	+79.0	0	44 54 36.0	8.8	-2' 27"	0	. .
4.34947	Milan	19.19	.45	8.5	2	57 50.3	8.6	+13.3	3	7
4.36638	Milan	28.53	.45	62.4	0	58 55.7	8.6	0.3	3	7
4.37342	Munich	26.53	.37	20.3	3	59 56.0	9.5	+24.6	1	. .
4.38462	Milan	30.77	.45	36.2	2	45 0 11.1	8.6	-18.1	3	9
4.40207	Paris	32.43	.35	4.4	2	1 56.1	9.5	+ 4.6	2	2
4.40421	Seeberg	35.13	.25	26.0	2	2 24.0	9.8	21.7	2	. .
4.42595	Dorpat	39.23	. .	7.4	3	4 20.6	. . .	22.5	2	Mer.
4.42746	Vienna	38.47	+0.10	- 7.3	1				. .	. .
4.46287	Berlin	49.27	. .	+12.9	1	7 24.0	10.2	+36.1	1	Mer.
4.47035	Seeberg	50.47	. .	+ 5.2	2	6 54.0	10.3	-31.1	0	Mer.
4.47646	Palermo	51.43	-0.03	- 0.6	2	8 1.0	7.8	+14.9	2	. .
4.47665	Mannheim	51.87	. .	+ 2.8	3	20.0	10.3	+85.0	0	Mer.
5.34405	Padua	59 42.40	+0.47	+1' 54".5	0	46 12 14.0	8.5	-48.9	0	. .
5.34881	Milan	33.59	.47	10.7	2	13 26.0	8.0	+ 0.6	3	9
5.36306	Milan	37.27	.47	11.8	2	14 33.9	8.0	9.0	3	9
5.36565	Munich	37.80	.39	10.3	3	49.0	9.0	+19.9	1	. .
5.42594	Dorpat	53.29	. .	10.3	3	18 43.7	. . .	- 6.9	2	Mer.
5.43493	Seeberg	56.07	+0.12	+17.1	2	19 22.0	9.7	+ 2.7	2	. .
5.45441	Vienna	58.40	. .	-10.1	2				. .	Mer.
5.46937	Palermo	7 0 2.73	-0.02	- 3.2	2	21 51.0	7.6	16.7	2	. .
5.47036	Seeberg	3.80	. .	+ 4.6	2	56.0	9.9	11.3	2	Mer.
5.47666	Mannheim	5.20	. .	+ 2.8	3	22 20.0	9.8	+10.1	1	Mer.
5.49995	Paris	10.20	. .	- 5.4	3	23 43.0	9.9	- 1.6	1	Mer.
5.51991	Greenwich	9.00	-0.08	69.4	0	25 2.0	9.7	4.1	2	. .
6.32231	Milan	3 30.79	+0.48	10.7	2	47 17 17.5	7.5	-1' 40"	0	9
6.33616	Milan	21.08	.48	-2' 23".5	0	16 34.9	7.5	+ 3.6	3	9
6.33882	Padua	37.33	.49	+15.5	2	15 21.0	8.2	-1' 16".9	0	. .
6.35249	Munich	38.60	.42	- 5.8	3	17 19.0	8.4	- 6.7	1	. .
6.37350	Munich	45.80	.35	+15.1	3	18 50.0	8.8	+11.2	1	. .
6.37620	Vienna	39.00	.30	-61.3	0				. .	. .
6.38830	Bremen	48.00	.30	+ 2.3	3	20 29.8	9.1	- 5.4	2	5
6.40386	Seeberg	52.20	.20	4.5	2	29.0	9.4	+ 4.9	2	. .
6.42573	Prague	4 1.63	+0.02	35.6	0				. .	5
6.42584	Dorpat	3 58.45	. .	+12.2	3	22 9.4	. . .	+20.1	2	Mer.
6.42960	Wilna	53.27	. .	-49.8	0	21 44.0	9.6	-1' 48".8	0	Mer.
6.45452	Vienna	4 4.33	. .	+ 1.9	1				. .	Mer.
6.46278	Berlin	7.33	. .	+12.3	1	24 26.0	9.4	+38.7	1	Mer.
6.46934	Palermo	7.07	-0.01	- 5.6	2	18.0	7.6	13.3	2	. .
6.47027	Seeberg	8.67	. .	+ 7.5	2	33.0	9.7	19.5	2	Mer.
7.32305	Milan	7 29.74	+0.48	9.4	2	48 9 37.9	7.2	11.7	3	9
7.33689	Milan	33.38	.48	+13.7	2	10 20.0	7.2	13.1	3	9
7.34944	Kremsmünster	33.20	.39	-18.1	1				. .	. .
7.35999	Munich	37.73	.38	+ 2.6	3	11 34.0	8.3	12.9	1	. .
7.37241	Vienna	41.81	.31	14.0	1				. .	6
7.41560	Seeberg	7 7 52.47	+0.38	+21.4	2	+48 13 54.0	+ 8.3	+ 1.1	2	. .

Date July	Place	α apparent $^{\circ}$	π $''$	O — C $\Delta\alpha \cos \delta$ $''$	Wt.	δ apparent $^{\circ}$	π $''$	O — C $\Delta\delta$ $''$	Wt.	*
7.42566	Dorpat	7 ^h 54.35	..	+13.1	3	+48 14 53.6	..	+23.6	2	Mer.
7.44937	Prague	8 0.48	+0.01	23.9	1	.. ..	..	..	..	11
7.45432	Vienna	7 59.67	..	0.0	2	.. ..	..	..	..	Mer.
7.47280	Palermo	8 3.93	-0.02	0.8	2	16 50.0	+ 7.2	15.0	2	..
7.48966	Greenwich	9.50	+0.04	19.0	2	17 41.0	8.8	15.8	2	..
7.56766	Padua	33.07	-0.39	+1' 9".0	0	21 16.0	8.4	+11.8	1	..
8.33792	Milan	11 19 35	+0.49	- 2.4	2	.. ..	..	..	..	9
8.34697	Milan	22.41	.49	+ 7.9	2	55 7.5	6.9	- 1.6	3	9, 12
8.35391	Milan	23.73	.49	5.7	2	33.1	6.9	+ 8.8	3	12
8.36519	Padua	27.33	.39	+15.3	2	56 21.0	8.1	32.6	1	..
8.37214	Vienna	27.46	.36	- 5.0	1	.. ..	..	..	..	8
8.44750	Greenwich	45.20	.31	+11.2	2	59 15.0	8.1	8.8	2	..
8.45069	Paris	45.39	+0.15	+ 4.0	2	31.3	8.7	+ 1.7	2	9
8.45399	Vienna	44.47	..	-13.6	2	.. ..	..	..	..	Mer.
8.47097	Palermo	52.60	-0.02	+30.1	2	58.0	6.8	- 2.0	2	..
8.49309	Paris	56.30	..	17.4	3	57.3	10.0	+ 2.6	1	Mer.
9.32158	Milan	14 55.40	+0.49	11.8	2	49 31 20.7	6.6	5.8	3	9, 12
9.33679	Milan	58.82	.49	13.5	2	59.2	6.6	+13.7	3	9, 12
9.33740	Padua	15 0.40	.46	27.1	2	44.0	7.2	- 1.4	1	..
9.39132	Paris	10.69	.35	14.1	2	33 44.8	6.4	+ 9.8	2	9, 12
9.42496	Dorpat	18.68	..	19.0	3	35 10.1	..	22.1	2	Mer.
9.42874	Wilna	20.00	..	24.0	1	19.1	8.4	32.3	1	Mer.
9.43817	Bremen	20.82	+0.12	13.5	3	8.0	8.5	1.6	2	9, 12
9.47901	Palermo	29.83	-0.04	16.2	2	36 36.0	6.5	11.7	2	..
9.49267	Paris	32.68	..	15.2	3	56.3	8.6	3.1	1	Mer.
10.32109	Milan	18 24.88	+0.49	14.7	2	50 2 10.0	6.3	13.6	3	9, 12
10.33540	Milan	27.66	.49	+13.4	2	32.1	6.2	+12.9	3	12
10.33619	Padua	25.60	.45	- 8.5	2	1 58.0	6.9	-22.6	1	..
10.35906	Paris	33.13	.43	+18.7	2	3 5.9	6.9	+ 8.1	2	12
10.35964	Padua	26.60	.38	-45.7	0	3 13.0	7.4	14.1	1	..
10.39565	Prague	39.14	.04	+ 0.5	1	.. ..	..	..	..	12
10.40872	Vienna	41.87	+0.30	4.0	1	.. ..	..	..	..	..
10.42821	Wilna	47.93	..	21.1	1	5 14.8	8.1	23.5	1	Mer.
10.45819	Prague	55.52	..	35.4	1	.. ..	..	..	..	Mer.
10.47929	Palermo	58.03	-0.04	18.7	2	6 37.0	6.4	23.9	2	..
11.32182	Milan	21 46.49	+0.47	23.3	2	27 19.9	6.2	12.1	3	12
11.33786	Milan	49.22	.47	19.3	2	44.5	6.2	10.3	3	12
11.34835	Padua	49.80	.40	4.1	2	59.0	7.0	10.9	1	..
11.39076	Seeberg	59.80	.25	18.7	2	29 15.0	7.5	+29.8	2	..
11.42776	Wilna	22 9.15	..	36.5	1	28 31.4	7.9	-1' 3".3	0	Mer.
11.45028	Paris	12.73	+0.15	+30.0	2	30 4.3	7.9	- 0.1	2	12
11.46090	Berlin	9.60	..	-21.0	0	50.0	8.0	+30.7	1	Mer.
11.47454	Mannheim	16.00	..	+14.4	3	31 20.0	8.0	42.7	0	Mer.
11.47922	Palermo	18.03	-0.03	25.3	2	30 56.0	5.9	13.3	2	..
11.49155	Paris	20.22	..	23.3	3	31 2.7	8.1	3.4	1	Mer.
11.49802	Greenwich	20.00	..	9.5	2	22.0	8.0	13.6	2	Mer.
12.32666	Milan	24 59.48	+0.43	20.5	2	48 18.9	6.1	21.2	3	12
12.34008	Palermo	25 1.93	.45	19.6	2	25.0	6.6	13.0	2	..
12.39360	Seeberg	13.07	.24	28.0	2	49 20.0	7.4	9.6	2	..
12.42250	Bremen	16.24	+0.16	+ 5.8	3	51.9	7.5	9.8	2	14
12.42697	Wilna	16.56	..	- 0.6	1	48.4	7.7	1.7	1	Mer.
12.46011	Berlin	24.13	..	+12.2	1	50 55.0	7.7	+31.9	1	Mer.
12.52777	Padua	42.20	-0.23	+1' 1".4	0	43.0	7.5	-53.1	0	..
13.32953	Milan	28 4.97	+0.44	25.4	2	51 4 59.9	6.1	+15.4	3	12
13.34909	Munich	8.33	.37	+23.2	3	5 37.0	6.7	34.8	1	..
13.36479	Vienna	8.27	+0.28	- 4.8	1	.. ..	..	..	..	..
13.42237	Dorpat	21.91	..	+23.2	3	6 26.8	..	12.7	2	Mer.
13.44973	Vienna	25.80	..	13.5	2	.. ..	..	..	..	Mer.
13.47333	Palermo	31.80	-0.05	30.2	2	7 15.0	5.8	+ 6.2	2	..
13.49005	Paris	34.07	..	23.2	3	0.0	7.6	- 5.9	1	Mer.
13.49384	Padua	7 28 34.00	-0.11	+15.1	2	+51 7 3.0	+ 7.6	- 6.0	1	..

Date July	Place	α apparent h m s	π s	O—C $\Delta\alpha \cos \delta$ "	Wt.	δ apparent ° ' "	π "	O—C $\Delta\delta$ "	Wt.	*
13.49653	Greenwich	7 28 34.50	. .	+16.2	2	+51 7 31.0	+ 7.6	+19.7	2	Mer.
13.55239	Paris	45.88	-0.21	26.1	2	8 12.1	7.3	13.3	2	15
14.32871	Milan	31 2.40	+0.44	30.8	2	13 26.7	6.1	+14.9	3	12
14.34229	Padua	1.67	.39	+ 1.1	2	13.0	6.6	- 8.3	1	. .
14.38570	Vienna	8.80	.21	- 3.8	1	. . .	. .	. .	. .	. .
14.40429	Berlin	16.47	.16	+37.4	1	19 28.0	7.1	+22.9	1	. .
14.40904	Paris	14.17	.26	9.1	2	28.7	6.9	21.4	2	15
14.41497	Bremen	15.45	+0.17	10.7	3	32.1	7.1	19.9	2	13, 15, 16
14.42525	Wilna	17.47	. .	11.3	1	56.5	7.3	+36.0	1	Mer.
14.46446	Florence	26.47	. .	32.1	1	46.0	7.5	- 1.1	1	Mer.
14.48361	Palermo	28.97	-0.06	24.3	2	20 18.0	5.7	+16.8	2	. .
14.48919	Paris	29.83	. .	23.7	3	19 56.6	7.4	- 8.0	1	Mer.
15.33187	Milan	33 53.06	+0.43	+31.7	2	29 8.7	+5.8	+13.9	2	12
15.34708	Munich	55.40	.35	+29.3	3	31.0	6.3	27.6	1	. .
15.36061	Vienna	53.87	.28	- 6.8	1	. . .	. .	. .	. .	. .
15.41139	Bremen	34 3.77	.17	+ 5.8	3	30 2.1	6.9	24.0	2	15, 16
15.42432	Wilna	33 59.90	. .	-51 9	0	31 10.6	7.0	+1' 24".6	0	Mer.
15.45797	Greenwich	34 19.40	+0.11	+78.9	0	30 11.0	7.1	6.4	2	. .
15.48347	Palermo	17.80	-0.06	23.5	2	37.0	5.6	18.3	2	. .
15.48823	Paris	18.53	. .	+22.9	3	47.0	7.2	25.9	1	Mer.
16.36529	Kremsmünster	36 37.60	+0.27	- 9.6	1	. . .	. .	. .	. .	. .
16.38722	Vienna	42.87	+ .19	+13.2	1	. . .	. .	. .	. .	. .
16.44821	Vienna	53.20	. .	18.0	2	. . .	. .	. .	. .	Mer.
16.46393	Seeberg	57.80	. .	29.1	2	38 34.0	6.8	22.9	2	Mer.
16.47022	Mannheim	57.93	. .	21.0	3	40.0	7.0	26.5	1	Mer.
16.47730	Seeberg	37 0.40	-0.04	33.0	2	34.0	6.8	17.3	2	. .
16.48721	Paris	0.97	. .	24.1	3	50.7	7.1	30.1	1	Mer.
17.32897	Milan	39 12.70	+0.41	25.3	2	43 50.4	5.6	15.4	3	12, 19
17.33904	Palermo	14.60	.40	28.1	2	51.0	5.8	+12.6	2	. .
17.36401	Padua	27.07	.30	+1' 47".2	0	3.0	6.3	-43.1	0	. .
17.46913	Mannheim	34.53	. .	23.4	3	45 0.0	6.9	+40.8	1	Mer.
17.48613	Paris	18.13	.33	16.9	2	44 7.0	6.0	17.6	2	19
18.33128	Milan	41 45.18	.39	29.8	2	48 39.6	5.5	23.2	3	19
18.36765	Padua	50.33	.28	26.4	2	40.0	6.2	27.8	1	. .
18.37756	Vienna	49.33	.21	3.2	1	. . .	. .	. .	. .	. .
18.39704	Prague	57.96	.03	53.9	0	. . .	. .	. .	. .	19
18.41455	Seeberg	57.87	.13	30.5	2	55.0	6.5	20.4	2	. .
18.41762	Bremen	57.86	.14	26.0	3	52.8	6.5	16.7	2	17, 18
18.42277	Paris	58.56	.19	26.3	2	43.6	6.6	7.5	2	19
18.44602	Vienna	42 1.60	. .	19.2	2	. . .	. .	. .	. .	Mer.
18.46171	Seeberg	5.00	. .	30.4	2	49 13.0	6.7	27.8	2	Mer.
18.46800	Mannheim	5.20	. .	23.5	3	40.0	6.7	53.4	0	Mer.
18.47500	Greenwich	10.50	+0.05	69.4	0	26.0	6.7	37.9	2	. .
18.48123	Palermo	7.83	-0.05	30.3	2	12.0	5.1	+22.0	2	. .
18.48498	Paris	7.90	. .	25.5	3	48 46.2	6.8	- 3.7	1	Mer.
19.33019	Milan	44 11.44	+0.37	31.6	2	51 48.8	5.4	+17.8	3	19
19.34273	Padua	13.33	.34	32.3	2	58.0	5.7	25.8	1	. .
19.34820	Munich	13 60	.31	27.0	3	55.0	5.8	+22.0	1	. .
19.36811	Kremsmünster	14.60	.24	9.2	1	. . .	. .	. .	. .	. .
19.37510	Prague	19.79	.04	+46.5	1	. . .	. .	. .	. .	19
19.38226	Vienna	13.33	.19	-22.1	0	. . .	. .	. .	. .	. .
19.40194	Berlin	20.33	.14	+16.6	1	29.0	6.4	-11.6	0	. .
19.42255	Seeberg	25.00	.11	32.2	2	59.0	6.5	+15.3	2	. .
19.42632	Bremen	27.03	+0.14	58.0	0	57.5	6.3	13.1	2	19
19.44475	Vienna	27.27	. .	22.6	2	. . .	. .	. .	. .	Mer.
19.45903	Florence	29.33	. .	22.9	1	53.0	6.7	4.2	1	Mer.
19.46050	Seeberg	30.53	. .	32.0	2	52 20.0	6.6	30.8	2	Mer.
19.46267	Göttingen	29.73	. .	+21.8	3	12.0	6.5	22.4	2	Mer.
19.47473	Palermo	28.53	-0.05	- 5.6	2	+51 52 30.0	+ 5.1	+ 8.8	2	. .
20.34510	Kremsmünster	46 32.20	+0.29	+ 8.3	1	. . .	. .	. .	. .	. .
20.34779	Prague	7 46 33.36	+0.05	+13.0	1	. . .	. .	. .	. .	19

Date	Place	α apparent	π	O—C $\Delta\alpha \cos \delta$	Wt.	δ apparent	π	O—C $\Delta\delta$	Wt.	*
20.37557	Vienna	7 46 36.87	+0.19	+11.6	1	...	...	...	...	...
20.41487	Dorpat	44.79	...	33.0	3	+51 54 22.1	...	+37.3	2	Mer.
20.41845	Wilna	44.96	...	29.8	1	9.7	+ 6.3	+30.8	1	Mer.
20.42502	Berlin	43.13	0.07	5.1	1	53 34.0	5.4	- 6.2	1	...
21.32761	Milan	48 48.56	.36	31.0	2	54 56.6	5.2	+24.2	3	19
21.33802	Milan	50.48	.36	+36.8	2	51.0	5.2	18.3	3	19
21.46007	Göttingen	49 2.27	...	- 9.4	0	58.0	6.3	22.5	2	Mer.
21.46990	Greenwich	48 39.00	.05	-3' 53".4	0	55 0.0	6.3	24.5	2	...
22.35418	Paris	51 4.08	.33	+31.6	2	54 52.1	5.3	11.8	2	19
22.39115	Seeberg	9.93	.17	39.6	2	43.0	5.9	3.9	2	...
22.41152	Dorpat	12.08	...	33.9	3	...	...	...	...	Mer.
22.45657	Seeberg	17.53	...	30.2	2	55 5.0	6.2	27.4	2	Mer.
22.45877	Göttingen	18.27	...	34.4	3	54 56.0	6.1	18.3	2	Mer.
22.48634	Greenwich	21.00	...	26.7	2	55 24.0	6.2	47.0	0	Mer.
23.33005	Palermo	53 8.60	+0.36	31.0	2	54 6.0	5.2	1.1	2	...
23.35840	Paris	12.39	-0.12	+28.5	2	25.5	6.1	22.9	2	19
23.36400	Vienna	8.07	.21	-14.9	0	...	...	...	...	...
23.41081	Dorpat	11.78	...	+37.3	3	45.8	...	40.2	2	Mer.
23.41107	Padua	18.73	+0.12	27.9	2	46.0	6.1	46.5	0	...
23.41532	Berlin	16.33	.19	1.9	1	21.0	5.7	+21.2	1	...
23.47845	Paris	27.14	...	26.1	3	53 46.5	6.1	- 9.1	1	Mer.
23.48492	Greenwich	27.00	...	+18.0	2	54 19.0	6.1	+73.8	0	Mer.
24.33558	Milan	55 13.63	+0.33	+35.9	2	53 20.5	+5.1	+28.6	3	19
24.33565	Kremsmünster	11.80	.28	18.6	1	...	...	...	...	...
24.38507	Paris	19.77	.24	36.3	2	18.1	5.5	30.9	2	19
24.40430	Bremen	22.14	+0.13	34.5	3	20.0	5.8	34.0	2	19, 20
24.40935	Dorpat	22.23	...	29.6	3	52 59.6	...	+ 9.2	2	Mer.
24.41301	Wilna	21.47	...	18.7	1	39.0	5.9	- 5.2	1	Mer.
24.47700	Paris	30.55	...	30.4	3	51.5	6.1	+13.4	1	Mer.
24.48348	Greenwich	30.00	...	18.0	2	53 3.0	6.0	25.3	2	Mer.
24.61872	Palermo	50.40	-0.46	50.9	2	52 32.0	4.1	5.4	2	...
25.33224	Milan	57 13.55	+0.33	38.8	2	51 29.9	5.1	21.4	3	19
25.34947	Kremsmünster	15.80	.24	39.6	1	...	...	...	...	...
25.35848	Padua	16.00	.25	31.8	2	41.0	5.5	36.0	1	...
25.37879	Vienna	16.73	.15	15.5	1	...	...	...	...	...
25.39152	Paris	20.05	.22	33.0	2	19.8	5.5	+18.7	2	19
25.39633	Munich	21.13	.14	37.1	3	50 52.0	5.8	- 8.2	1	...
25.41161	Wilna	20.80	...	15.9	1	51 38.4	5.8	+40.1	1	Mer.
25.41931	Bremen	23.29	+0.09	30.6	3	32.4	5.8	34.5	2	19, 20
25.43646	Vienna	25.40	...	31.4	2	...	...	...	...	Mer.
25.47553	Paris	29.98	...	31.2	3	18.5	6.0	28.1	1	Mer.
25.48200	Greenwich	30 00	...	25.2	2	23.0	5.9	+32.6	2	Mer.
25.61604	Palermo	46.80	-0.45	30.1	2	50 31.0	4.1	- 4.1	2	...
26.36865	Prague	59 13.83	+0.04	31.6	1	...	...	...	...	19
26.37755	Vienna	11.40	.22	2.8	1	...	...	...	...	...
26.40523	Bremen	17.81	+0.12	+29.7	3	49 21.0	5.6	+32.3	2	20
26.40673	Dorpat	...	...	...	...	12.9	...	18.6	2	...
26.41000	Wilna	13.28	...	-17.5	0	0.3	5.6	13.1	1	Mer.
26.43546	Vienna	17.93	...	+19.8	2	...	...	...	...	Mer.
26.45292	Göttingen	24.67	...	42.5	3	48 49.0	5.8	8.1	2	Mer.
26.47402	Paris	27.42	...	45.4	3	49 10.0	5.9	32.3	1	Mer.
26.48048	Greenwich	26.00	...	25.7	2	5.0	5.8	+28.1	2	Mer.
26.60812	Palermo	41.07	-0.43	26.3	2	48 13.0	4.0	- 7.0	1	...
27.33118	Milan	8 1 8.09	+0.30	+1' 24".1	0	46 38.3	5.1	+10.7	3	19
27.34079	Padua	4.13	.27	36.9	2	47 9.0	5.1	42.9	1	...
27.34603	Kremsmünster	0.87	.23	1.3	1	...	...	...	...	...
27.37395	Prague	8.37	.03	39.8	1	...	...	...	...	19
27.38647	Vienna	5.60	.20	2.9	1	...	...	...	...	...
27.39849	Seeberg	9.80	+ .13	28.8	2	...	...	...	...	...
27.40482	Dorpat	11.70	...	+38.7	3	46 38.5	...	17.6	2	Mer.
27.40842	Wilna	8 1 5.67	...	-21.0	0	+51 46 19.0	+ 5.6	+ 4.3	1	Mer.

Date July	Place	α apparent $^{\circ}$ $'$ $''$	π $''$	O—C $\Delta\alpha \cos \delta$ $''$	Wt.	δ apparent $^{\circ}$ $'$ $''$	π $''$	O—C $\Delta\delta$ $''$	Wt.	*
27.41007	Berlin	8 1 9.87	+0.08	+17.0	1	+51 46 28.0	+ 5.7	+13.8	1	..
27.43393	Vienna	11.60	..	7.6	2	.. ..	..	..	..	Mer.
27.44916	Seeberg	15.07	..	24.2	2	46 17.0	5.7	9.1	2	Mer.
27.45133	Göttingen	14.87	..	20.0	3	.. ..	..	..	..	Mer.
28.33257	Kremsmünster	2 51.60	0.26	21.8	1	.. ..	..	..	..	..
28.36018	Vienna	58.57	.18	58.1	0	.. ..	..	..	..	..
28.36563	Prague	57.09	.03	37.2	1	.. ..	..	..	..	19
28.40323	Dorpat	3 1.04	..	36.0	3	44 8.8	..	37.9	2	Mer.
28.40691	Wilna	1.78	..	39.0	1	13.0	5.6	+48.3	1	Mer.
28.42222	Paris	2 59.48	+0.14	3.7	2	43 20.5	5.5	— 1.4	2	19
28.43235	Vienna	3 1.73	..	16.8	2	.. ..	..	..	..	Mer.
28.44267	Mannheim	4.07	..	24.5	3	40.0	5.7	+20.1	1	Mer.
28.44513	Munich	4.20	..	23.2	3	38.0	5.7	20.2	1	Mer.
28.44976	Göttingen	..	..	..	..	46.0	5.6	29.3	3	..
28.47383	Palermo	7.80	—0.06	+27.4	2	37.0	4.5	22.7	2	..
29.34325	Kremsmünster	4 36.60	+0.23	— 7.8	0	.. ..	..	..	..	..
29.36899	Vienna	41.27	.15	+ 9.5	1	.. ..	..	..	..	..
29.37443	Prague	44.39	.03	31.8	1	.. ..	..	..	..	19
29.40526	Wilna	45.81	..	14.7	1	41 3.4	5.4	42.5	1	Mer.
29.41804	Seeberg	49.53	+0.07	37.4	2	.. ..	..	..	..	..
29.44352	Munich	51.40	..	29.3	3	40 54.0	5.6	40.5	1	Mer.
29.45007	Mannheim	52.13	..	29.7	3	38.0	5.6	25.8	1	Mer.
29.62546	Palermo	5 11.40	—0.43	33.8	2	39 57.0	3.8	+16.7	2	..
30.33134	Padua	6 23.47	+0.27	29.5	2	37 17.0	4.9	— 3.0	1	..
30.37014	Vienna	26.53	.14	19.3	1	.. ..	..	..	..	..
30.39927	Dorpat	31.72	..	38.5	3	31.1	..	+19.1	2	Mer.
30.40359	Wilna	29.60	..	14.7	1	31.2	5.4	25.5	1	Mer.
30.40587	Paris	31.81	.15	34.6	2	16.7	5.3	11.5	2	19
30.44649	Göttingen	35.47	..	28.4	3	23.0	5.4	25.9	2	Mer.
30.46760	Paris	37.90	..	30.8	3	1.0	5.6	8.4	1	Mer.
31.35019	Padua	8 7.07	+0.22	+30.9	2	33 54.0	+5.0	+ 1.3	1	..
31.37288	Vienna	8.13	.13	18.9	1	.. ..	..	..	..	..
31.37832	Prague	9.97	.02	29.6	1	.. ..	..	..	..	19
31.38284	Seeberg	12.13	.14	47.1	2	.. ..	..	..	..	..
31.39829	Dorpat	13.51	..	43.9	3	.. ..	..	..	..	Mer.
31.40141	Paris	12.55	+0.15	+33.6	2	34 0.4	5.3	18.6	2	19
31.40187	Wilna	6.63	..	—23.4	0	15.2	5.3	33.3	1	Mer.
31.42740	Vienna	14.33	..	+33.8	2	.. ..	..	..	..	Mer.
31.46664	Paris	21.16	..	51.8	3	33 32.7	5.5	+ 4.8	1	Mer.
31.49704	Kremsmünster	20.27	—0.16	+13.7	1	.. ..	..	..	..	..
31.60460	Palermo	27.00	—0.41	—25.7	0	0.0	3.8	— 0.8	2	..
August										
1.32376	Padua	9 44.00	+0.27	+37.6	2	30 57.0	4.7	+29.3	1	..
1.33488	Milan	45.83	.26	47.8	2	31 1.6	5.0	36.6	3	19
1.37116	Vienna	48.00	.13	30.5	1	.. ..	..	..	..	..
1.37659	Prague	54.09	.02	81.0	0	.. ..	..	..	..	19
1.39433	Seeberg	51.07	+0.11	38.1	2	30 22.0	5.3	7.8	2	..
1.40020	Wilna	49.92	..	+20.9	1	47.3	5.3	36.6	1	Mer.
1.42564	Vienna	48.73	..	—13.2	0	.. ..	..	..	..	Mer.
1.46421	Paris	57.47	..	+33.2	3	.. ..	5.4	5.3	1	Mer.
1.49615	Kremsmünster	58.67	—0.16	13.9	1	.. ..	..	..	..	..
2.33164	Padua	11 21.47	+0.25	40.5	2	28 58.0	4.8	+2' 7".7	0	..
2.39841	Wilna	25.16	..	13.3	1	27 0.1	5.2	24.6	1	Mer.
2.42395	Vienna	27.33	..	11.0	2	.. ..	..	..	..	Mer.
3.33503	Milan	12 55.50	.25	37.6	2	23 30.1	5.0	17.9	3	19
3.35584	Milan	57.66	+0.21	39.4	2	30.3	5.0	22.6	3	19
3.39671	Wilna	13 1.44	..	37.2	1	1.3	5.2	3.6	1	Mer.
3.43962	Göttingen	4.60	..	29.6	3	25.0	5.2	37.5	2	Mer.
3.61719	Palermo	21.87	—0.41	38.6	2	22 29.0	3.4	17.5	2	..
4.39130	Dorpat	14 33.07	..	41.8	3	19 37.9	..	15.1	2	Mer.
4.39492	Wilna	8 14 32.16	..	+30.2	1	+51 19 48.5	+ 5.1	+31.6	1	Mer.

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SECONDARY NUCLEUS TO COMET *b* 1906 (*KOPFF'S*, March 3),

By E. E. BARNARD.

On March 17—the first observation of this comet here—I noticed with the 40-inch telescope a faint star-like condensation close preceding the nucleus. The unusually slow motion of the comet made it uncertain whether the object was a faint star or a secondary nucleus. It was seen again, however, on March 24, at a somewhat greater distance from the nucleus, and was (as before) involved in the tail, and rather difficult to see. By hiding the brighter part of the comet the object appeared as a small star-like nucleus. The following position is referred to the nucleus of the comet:

1906 March 24^d 18^h 40^m Gr. M.T.

Position-angle, 300°.0 (5 obs.) Distance, 4".68 (4 obs.)

The second nucleus was about 14^m–15^m.

If this object were free from the nebulosity of the main body, it would doubtless appear as a distinct comet—like

Yerkes Observatory, 1906 March 26.

one of the companions of comet V 1889. It is a similar case to that of SWIFT's comet (*a* 1899), which was observed here and at the Lick Observatory to have a second nucleus or small comet receding from it (see *A.J.* 464).

Looking back over the past twenty-five years at the various cases of double or multiple comets, it would appear that BIELA's double comet was not such a rare object after all.

The following additional observation of the double head of KOPFF's comet has been made:

1906 March 31^d 13^h 0^m Central Standard Time.

Position-angle 302°.7 Distance 5".67.

There seems to be a slight change in the angle and distance, but it is quite difficult to measure satisfactorily. The small nucleus is 3 or 4 magnitudes fainter than the principal one.

COMET *c* 1906 (*ROSS*, March 17),

A comet was discovered by Ross, at Melbourne, Australia, on March 17, in the position first given below. It is described as circular, 3' diameter, brightness 8^m, with some central condensation.

The other positions below were observed by Prof. H. R. MORGAN, of the Morrison Observatory, Glasgow, Missouri, and received by telegraph *via* Harvard College Observatory.

1906 Gr. M.T.	<i>a</i>	<i>δ</i>	Observer
Mar. 17.914	2 ^h 3 ^m 52 ^s	−7° 41' −"	Ross
19.5779	2 9 31.4	−5 47 25	Morgan
21.5782	2 16 3.8	−3 35 21	Morgan
22.5773	2 19 3.7	−2 32 29	Morgan

The following elements and ephemeris, telegraphed by Admiral ASA WALKER, Superintendent Naval Observatory,

Washington, also *via* H.C.O., were computed by Miss ELEANOR LAMSON, from observations of Mar. 19, 20, 21.

ELEMENTS.

T = 1906 Feb. 21.47 Gr. M.T.

$$\begin{aligned} \omega &= 278^{\circ} 43' \\ \Omega &= 72^{\circ} 51' \\ i &= 81^{\circ} 27' \end{aligned} \left. \vphantom{\begin{aligned} \omega \\ \Omega \\ i \end{aligned}} \right\} 1906$$

$$q = 0.743$$

EPHEMERIS.

1906	<i>a</i>	<i>δ</i>	Br.
March 25	2 ^h 27 ^m 47 ^s	+ 0° 26'	0.67
29	38 45	4 11	
April 2	48 52	7 36	
6	2 58 17	+10 42	0.39

Date	Place	α apparent	π	O—C	Wt.	δ apparent	π	O—C	Wt.	*
August		$^{\circ}$ $'$ $''$	$''$	$''$		$^{\circ}$ $'$ $''$	$''$	$''$		
4.43137	Seeberg	8 14 37.73	+0.01	+51.2	2	+51 20 5.0	+5.2	+56.2	0	..
4.43783	Göttingen	35.67	..	26.8	3	19 46.0	5.2	38.6	2	Mer.
4.60860	Palermo	53.27	-0.40	43.4	2	18 51.0	3.5	19.7	2	..
5.35822	Prague	15 56.87	+0.03	16.0	1	.. ..	..	..	..	19
5.38951	Dorpat	16 2.61	..	43.8	3	16 6.7	..	24.1	2	Mer.
5.39310	Wilna	15 59.90	..	15.7	1	16 41.1	5.1	+1' 4".4	0	Mer.
5.60049	Palermo	16 21.73	-0.39	45.6	2	14 52.0	3.5	- 0.6	2	..
6.38698	Dorpat	17 28.70	..	34.4	3	.. ..	..	..	..	Mer.
6.39134	Wilna	32.16	..	+1' 3".4	0	12 10.3	5.0	+12.9	1	Mer.
7.38587	Dorpat	18 55.40	..	47.4	3	.. ..	..	..	..	Mer.
7.39012	Wilna	52.65	..	18.5	1	8 54.4	4.9	34.5	1	Mer.
7.40273	Paris	57.83	+0.06	57.8	2	51.0	5.0	35.2	2	15
7.45348	Paris	19 1.07	..	47.4	3	.. ..	..	..	..	Mer.
8.33398	Padua	20 14.00	+0.15	43.8	2	5 32.0	4.8	35.4	1	..
8.38399	Dorpat	18.56	..	46.7	3	34.4	..	+42.4	2	Mer.
8.45161	Paris	23.60	..	41.6	3	3 58.5	5.0	-33.2	0	Mer.
8.59532	Palermo	35.27	-0.38	36.6	2	4 10.0	3.4	+ 7.3	2	..
9.38210	Dorpat	21 39.26	..	40.2	3	1 16.4	..	25.1	2	Mer.
9.38573	Wilna	37.33	..	19.1	1	2 15.2	4.9	+60.5	0	Mer.
9.59835	Palermo	58.40	-0.38	53.0	2	0 28.0	3.4	- 3.8	2	..
10.34071	Padua	55.00	+0.18	+34.8	2	50 57 19.0	4.6	38.3	..	..
10.38382	Wilna	50.11	..	-45.0	0	36.1	4.8	12.2	..	Mer.
10.44782	Paris	23 4.20	..	+40.6	3	56 56.2	5.0	-38.9	1	Mer.
11.44584	Paris	24 20.47	..	+27.0	3	54 18.0	+4.9	+ 3.8	1	Mer.
11.60136	Palermo	34.20	-0.39	40.2	2	53 44.0	3.0	- 1.3	2	..
12.35468	Munich	25 31.87	+0.13	48.1	3	51 39.0	4.7	+ 22.4	1	..
12.36221	Vienna	34.60	.09	68.4	1	.. ..	..	..	..	..
12.37635	Dorpat	33.44	..	46.3	3	46.8	..	+28.3	2	Mer.
12.41726	Seeberg	36.20	.01	43.3	2	.. ..	..	..	..	..
13.36232	Seeberg	26 47.67	.11	54.8	2	47 51.0	4.7	-14.4	0	..
13.37162	Munich	47.00	.10	41.0	3	48 31.0	4.7	+27.4	1	..
13.37440	Dorpat	47.96	..	46.7	3	.. ..	..	..	..	Mer.
13.44201	Paris	51.67	..	34.9	3	47 47.0	4.8	- 3.4	1	Mer.
14.32676	Padua	27 54.20	.19	17.7	2	44 16.0	4.4	52.8	0	..
14.38616	Vienna	59.70	+0.03	27.6	1	.. ..	..	..	..	22
14.44006	Seeberg	28 4.00	-0.05	+30.9	2	.. ..	..	..	..	..
15.43751	Paris	29 10.80	..	- 9.0	..	41 52.0	4.8	- 2.1	1	Mer.
16.33524	Vienna	30 19.35	+0.13	+48.6	1	.. ..	..	..	..	22
16.33798	Prague	23.32	.02	85.4	0	.. ..	..	..	..	23
16.36608	Seeberg	18.53	.09	19.8	2	.. ..	..	..	..	..
16.41678	Paris	24.29	.04	41.3	2	.. ..	..	..	..	15
17.31690	Padua	31 25.20	+0.19	37.7	2	38 23.0	4.3	+1' 37".8	0	..
17.45996	Paris	38.24	-0.06	67.7	2	36 56.2	4.7	34.9	2	15
18.35040	Prague	32 37.90	+0.02	73.4	0	.. ..	..	..	..	23
18.40606	Bremen	38.33	..	40.4	3	34 37.0	4.6	37.5	2	Mer.
18.45196	Paris	44.91	-0.05	73.9	0	2.3	4.6	10.8	2	15
19.34770	Bremen	33 38.87	+0.11	33.8	3	32 14.0	4.4	28.8	2	..
19.37317	Seeberg	40.67	.07	34.9	2	.. ..	..	..	..	..
20.33003	Padua	34 48.93	.15	+1' 45".6	0	29 58.0	4.4	24.9	1	..
21.35407	Bremen	35 46.40	.10	45.8	3	27 46.0	4.4	21.3	2	..
21.37264	Paris	45.93	.10	31.4	2	27.5	4.4	6.0	2	28
22.32025	Padua	36 47.60	.14	69.9	2	26 16.0	4.3	+42.7	1	..
22.35724	Bremen	45.27	.09	26.0	3	.. ..	..	..	..	..
22.37126	Seeberg	47.20	.06	36.0	2	.. ..	..	..	..	..
22.39139	Paris	47.32	.06	26.1	2	25 3.5	4.5	-17.2	1	28, 29
23.32029	Padua	37 46.07	+0.15	+61.5	2	23 17.0	+4.3	-30.1	1	..
23.34583	Vienna	43.33	.07	20.3	1	.. ..	..	..	..	..
23.35112	Seeberg	47.60	.09	58.3	2	.. ..	..	..	..	..
23.35399	Dorpat	46.00	..	42.0	3	.. ..	..	..	..	Mer.
23.35127	Prague	44.45	.01	33.7	1	.. ..	..	..	..	21
23.36675	Paris	8 37 48.03	+0.11	+54.3	2	+50 23 55.2	+4.3	+13.4	2	28, 29

Date	Place	α apparent	π	O—C	Wt.	δ apparent	π	O—C	Wt.	*
August		$^{\circ} \quad ' \quad ''$	$''$	$\Delta\alpha \cos \delta$		$^{\circ} \quad ' \quad ''$	$''$	$\Delta\delta$		
23.46692	Kremsmünster	8 37 55.60	—0.15	+67.7	1	...	...	...	...	...
24.32104	Padua	38 43.00	+0.15	51.5	2	+50 23 17.0	+4.3	+66.5	1	...
24.32690	Prague	39.46	.02	15.4	0	...	...	...	...	28, 21
24.33049	Vienna	41.07	.10	27.5	1	...	...	...	...	...
24.34749	Seeberg	44.87	.09	54.4	2	...	...	...	...	...
24.35189	Dorpat	45.25	...	54.2	3	...	...	...	...	Mer.
24.35727	Bremen	44.73	.08	47.6	3	21 37.0	4.4	—30.2	1	...
25.35127	Seeberg	39 42.73	+0.09	65.9	2	...	...	...	...	...
25.50391	Paris	48.19	—0.17	34.9	2	21 14.0	4.1	+45.0	2	29
26.33037	Bremen	40 31.00	+0.12	+ 6.7	1	19 38.0	4.2	35.5	2	...
26.34063	Prague	29.60	+0.01	— 0.6	0	...	...	...	...	21
26.46677	Kremsmünster	40.60	—0.16	+31.6	1	...	...	...	...	...
27.34543	Dorpat	41 29.94	...	55.0	3	...	...	...	...	Mer.
28.33288	Prague	42 15.65	+0.01	6.4	...	...	...	...	...	21
28.34324	Dorpat	21.75	...	52.8	3	...	...	...	...	Mer.
29.32808	Bremen	43 12.67	.11	63.4	3	17 24.0	4.3	41.8	2	...
30.31838	Prague	44 57.69	+0.02	32.1	1	...	...	...	...	21
30.44255	Kremsmünster	11.53	—0.15	99.2	0	...	...	...	...	...
30.49316	Paris	6.64	.15	29.2	2	16 21.2	4.1	+18.8	2	28, 29
September										
1.54381	Seeberg	45 43.27	—0.15	32.1	2	14 57.0	3.3	—34.3	1	...
9.32183	Bremen	50 55.53	+0.07	+48.0	3	19 42.0	+4.1	—62.9	0	...
10.32563	Bremen	51 27.93	.06	35.2	3	21 54.0	4.1	22.6	2	...
11.35010	Bremen	52 0.73	+0.02	34.4	3	23 41.0	4.1	21.7	2	...
13.38365	Dorpat	53 2.10	—0.11	42.0	3	27 30.6	—3.8	—48.6	2	24, 26
14.30547	Prague	25.87	+0.01	30.8	1	...	...	...	...	23
15.30429	Prague	52.89	.01	41.5	1	...	...	...	...	23
15.31315	Bremen	54.40	+0.06	52.5	3	33 12.0	+4.1	+17.6	2	...
15.33748	Dorpat	57.58	—0.10	75.3	0	32 28.4	—3.8	—37.9	2	26
16.29316	Prague	54 18.70	+0.01	59.3	1	...	...	...	...	23
17.30713	Bremen	40.13	.07	42.2	3	38 59.0	4.0	+23.3	2	...
18.30140	Prague	55 1.81	.01	51.7	1	...	...	...	...	23
19.29931	Bremen	20.07	+0.07	50.6	3	46 0.0	4.0	+53.8	0	...
23.36293	Dorpat	56 22.21	—0.12	+59.7	3	51 00 0.1	+ 3.7	—59.0	2	27
24.34153	Bremen	30.87	.02	48.8	3	6 18.0	4.1	+58.2	2	...
24.35550	Dorpat	37.07	.11	105.2	0	5 0.1	3.7	—23.7	2	27
24.53037	Bremen	34.33	.26	63.1	3	6 51.0	2.7	+38.0	2	...
25.36067	Dorpat	44.08	.12	93.4	0	10 31.9	3.7	23.5	2	27
October										
12.29163	Bremen	53 23.60	—0.02	+ 6.5	3	53 0 52.0	+4.0	+31.2	2	...
12.32982	Dorpat	25.00	.14	28.2	3	+53 0 22.0	+3.5	—23.9	2	...
15.31612	Dorpat	8 51 42.08	—0.14	+86.2	3	...	...	...	...	...

The weights attached to the observations were determined by plotting the residuals, and computing the mean error of the various series with regard to this curve. In forming the Normal Places, the observations of each single day were united into a weighted mean. These means were then used as the basis of equations of the form $x + ty = n$, by whose solution the position of the comet was found. The perturbations were computed for all the planets except *Uranus* and *Neptune*. Naturally they are small, as the comet very rapidly receded from the plane of the solar system. The positions for the dates of the Normal Places and the perturbations are

	$\Delta\alpha \cos \delta$	Per.	Wt.	$\Delta\delta$	Per.	Wt.
July 5.0	+ 5.88	+0.01	120	+ 6.57	0.00	88
11.0	15.50	3	126	11.42	0.00	100
19.0	24.81	6	124	19.45	+0.02	87
27.0	29.05	8	124	20.36	4	77
Aug. 4.0	37.47	9	95	17.48	10	54
16.0	39.66	10	61	14.27	21	26
26.0	46.54	11	44	+26.14	34	13
Sept. 14.0	44.16	8	25	—11.47	69	12
24.0	57.20	+0.05	9	+ 7.4	86	10
Oct. 14.0	+40.30	—0.06	9	+ 3.6	+1.37	4

The differential equations are

$$\begin{aligned}
 & -8.9027 \partial \kappa + 9.4232 \kappa \sqrt{2} \partial T + 9.4048 \partial q + 9.5013 \partial \lambda + 9.5094 \partial \nu - 8.1719 \frac{\partial e}{2} - 0.7701 = 0 \\
 & \begin{array}{rcccccc}
 -9.0860 & +9.4278 & +9.5985 & +9.2028 & +9.6362 & -7.9716 & -1.1912 \\
 -9.2435 & +9.4173 & +9.7135 & +7.9439 & +9.6877 & +8.0306 & -1.3957 \\
 -9.3419 & +9.3955 & +9.7699 & -8.9773 & +9.7039 & +8.5216 & -1.4643 \\
 -9.4105 & +9.3733 & +9.8032 & -9.2303 & +9.7092 & +8.7206 & -1.5747 \\
 -9.4863 & +9.3431 & +9.8353 & -9.4064 & +9.7118 & +8.8617 & -1.5994 \\
 -9.5351 & +9.3228 & +9.8547 & -9.4943 & +9.7146 & +8.9061 & -1.6688 \\
 -9.6057 & +9.2917 & +9.8803 & -9.6099 & +9.7275 & +8.8542 & -1.6458 \\
 -9.6329 & +9.2773 & +9.8885 & -9.6616 & +9.7406 & +8.7169 & -1.7578 \\
 -9.6590 & +9.2432 & +9.8851 & -9.7588 & +9.7810 & -8.3200 & -1.6053 \\
 +8.8721 & -9.9826 & +9.7648 & -7.3455 & -7.3536 & +9.1590 & -0.8176 \\
 -9.1773 & -9.5698 & +9.8988 & -8.1949 & -8.6283 & +9.3722 & -1.0577 \\
 -9.4967 & -9.0255 & +9.9723 & -7.2148 & -8.9586 & +9.5725 & -1.2894 \\
 -9.6126 & -8.3753 & +9.9963 & +8.3769 & -9.1035 & +9.7118 & -1.3096 \\
 -9.6789 & +7.7766 & +0.0050 & +8.7095 & -9.1884 & +9.8157 & -1.2450 \\
 -9.7456 & +8.3252 & +0.0103 & +8.9663 & -9.2714 & +9.9325 & -1.1608 \\
 -9.7895 & +8.4210 & +0.0163 & +9.1023 & -9.3226 & +0.0104 & -1.4229 \\
 -9.8619 & +8.5260 & +0.0352 & +9.2803 & -9.3979 & +0.1279 & +1.0326 \\
 -9.8990 & +8.5961 & +0.0514 & +9.3514 & -9.4304 & +0.1800 & -0.9170 \\
 -9.9706 & +8.7586 & +0.0930 & +9.4516 & -9.4738 & +0.2605 & -0.6964
 \end{array}
 \end{aligned}$$

From these by the ordinary least-square methods :

$$\begin{aligned}
 \partial \kappa - 9.5271 \kappa \sqrt{2} \partial T - 0.3446 \partial q + 9.0216 \partial \lambda - 9.7251 \partial \nu - 9.9915 \frac{\partial e}{2} + 1.8368 &= 0 \\
 \kappa \sqrt{2} \partial T - 9.7274 \partial q + 8.4489 \partial \lambda + 9.7204 \partial \nu - 9.6058 \frac{\partial e}{2} - 0.9173 &= 0 \\
 \partial q + 8.8517 \partial \lambda + 0.0171 \partial \nu - 9.6769 \frac{\partial e}{2} - 1.6827 &= 0 \\
 \partial \lambda - 9.7769 \partial \nu - 9.7855 \frac{\partial e}{2} + 1.7027 &= 0 \\
 \partial \nu - 9.1604 \frac{\partial e}{2} - 1.3297 &= 0 \\
 \frac{\partial e}{2} + 1.0926 &= 0
 \end{aligned}$$

And finally,

$$\begin{array}{l|l}
 \partial \kappa = -11.50 & \partial \lambda = -31.11 \\
 \kappa \sqrt{2} \partial T = +6.78 & \partial \nu = +19.57 \\
 \partial q = +24.14 & \frac{\partial e}{2} = -12.38
 \end{array}$$

When these values of the unknown quantities are substituted in the original equations the residuals are

$$\begin{array}{cc|cc}
 \Delta \alpha \cos \delta & \Delta \delta & \Delta \alpha \cos \delta & \Delta \delta \\
 +0.5 & +1.7 & +1.2 & +0.5 \\
 -0.9 & -3.7 & +5.2 & +14.5 \\
 -0.5 & +0.3 & -2.5 & -18.2 \\
 -1.7 & +1.6 & +7.7 & +2.7 \\
 +3.1 & +0.4 & -14.9 & +1.1
 \end{array}$$

On account of the predominance of the positive sign in the declination residuals, and the excessive values for Aug. 26 and Sept. 14, these latter were entirely omitted, and a second solution was made. Also, OLBERS's observation for

Oct. 12 was removed from the last normal place in right ascension, as it differs by nearly a minute of arc from the ephemeris place that is in accord with the other normal places, and by its presence gives rise to the large negative residual in this last normal in right-ascension. With these modifications there now results :

$$\begin{array}{l|l}
 \partial \kappa = -47.4 & \partial \lambda = -26.1 \\
 \kappa \sqrt{2} \partial T = -4.1 & \partial \nu = +22.5 \\
 \partial q = +14.0 & \frac{\partial e}{2} = -21.5
 \end{array}$$

and the residuals are

$$\begin{array}{cc|cc}
 \Delta \alpha \cos \delta & \Delta \delta & \Delta \alpha \cos \delta & \Delta \delta \\
 +0.3 & +1.1 & 0.0 & -1.1 \\
 -0.4 & -2.7 & +3.2 & . \\
 -0.2 & +1.1 & -6.1 & . \\
 -1.7 & +1.6 & +3.5 & -0.3 \\
 +2.7 & -0.2 & -3.3 & -3.1
 \end{array}$$

Corresponding to this new series of values of the unknown quantities are the following corrections to the elements:

$$\begin{array}{l|l} \partial T = -0.00083 & \partial \omega = -52''.4 \\ \partial \Omega = +30''.9 & \partial q = +0.000068 \\ \partial i = +15.8 & \partial e = -0.000208 \end{array}$$

Computing the probable errors the definitive elements are

$$\begin{array}{l} T = 1819 \text{ June } 27.71464 \pm 0.00037 \\ \left. \begin{array}{l} \Omega = 273^{\circ} 42' 2.9'' \pm 4.7'' \\ i = 80^{\circ} 44' 53.8'' \pm 2.7'' \\ \omega = 13^{\circ} 25' 21.6'' \pm 21.4'' \end{array} \right\} 1819.0 \\ \log q = 9.533319 \pm 0.000041 \\ e = 0.999792 \pm 0.000079 \end{array}$$

Syracuse University, 1906 Feb. 1.

EQUATORIAL COORDINATES.

$$\begin{array}{l} x = [9.237881] r \sin (35^{\circ} 20' 18.1'' + v) \\ y = [9.996719] r \sin (260^{\circ} 41' 39.4'' + v) \\ z = [9.996738] r \sin (349^{\circ} 49' 28.2'' + v) \end{array}$$

The coefficients in the differential equations were tested by the method of arbitrary variation of the elements at the beginning of the work. In order to test the accuracy of the definitive elements the position of the comet was computed for the date of the last normal place with the result:

$$\Delta \alpha \cos \delta = -3''.8, \quad \Delta \delta = -3''.6$$

In conclusion, I wish to express my thanks to the staff of astronomers at the Harvard Observatory for the many courtesies extended during the collection of the observations used as a basis for the computation.

MR. STOCKWELL ON THE THEORY OF TIDAL FRICTION,

By SIR GEORGE DARWIN.

As MR. STOCKWELL's name is well known for his contributions to Dynamical Astronomy, it seems advisable that his paper on this subject in the *Astronomical Journal* (No. 581, Jan. 15, 1906) should be noticed.

After some general remarks, and an extract from my book, "*The Tides*," he proves by numerical examples the well-known result, that in the variational curve, the moon's radius-vector in syzygies is less than in quadratures. This is taken to show that a body detached from the earth must necessarily collide with and be re-absorbed by the earth. It does prove it if the detachment occurs in quadratures, but not so if it occurs with a proper velocity in syzygies. However, the whole argument seems to me beside the point.

I prove that the moon may be traced back to a position near the earth, and that it then had no motion relatively to the earth. Such a position is one of dynamical instability, and mathematical analysis is powerless to trace the configuration of the system in retrospect behind such a stage. This primitive configuration of the moon seems, to me at least, to indicate a previous detachment from the earth of the matter now forming the moon; but the process of such a detachment escapes our powers of analysis. Mr. STOCKWELL's argument only shows that one particular mode of separation of the moon from the earth leads to a difficulty, unless the separation occurs at syzygy.

He next proceeds to discuss tidal friction, and gives a table of numerical values, which seems to me redundant. He then follows FERREL in placing the tidal apex, under the influence of friction, eastward of the moon. He omits to remark that this is the correct supposition for "direct"

tides, when, save for tidal friction, the figure would be a prolate ellipsoid, with longest axis directed to the moon; but incorrect for shallow oceans when the tides are "inverted," and the figure approximates to an oblate ellipsoid with minor axis pointed to the moon. In the latter case under friction the minor axis is directed westward of the moon.

We now come to the fundamental error in his argument. Following FERREL's supposition, he correctly finds that the moon's radius-vector is augmented, and her mean angular motion retarded. He then says, "Now, since action and reaction are equal, and in opposite directions, it follows that a *negative* secular equation of the moon's motion from this cause must produce a *positive* secular equation of the tidal sphere, which is supposed to be attached to the earth's surface, and thereby *increase* the earth's velocity of rotation." This is an erroneous appeal to the equality of action and reaction, and that it must be incorrect may be shown by the following argument. He finds an increase in the moon's radius-vector, and therefore the sum of the potential and kinetic energies of the moon's orbital motion is increased. If now the earth's rotation increases, the kinetic energy of rotation increases, and thus the whole effect of tidal friction is to augment the energy of the system; which is absurd. In fact, the earth's rotation is retarded, and that to such an extent as to make the whole energy of the system decrease. Action and reaction are, of course, equal and opposite, but the argument is incorrectly applied by Mr. STOCKWELL.

I would refer the reader to Appendix G (*b*) in THOMSON and TAIT's *Natural Philosophy*, or to Art. "*Tides*," §46,