DEFINITIVE DETERMINATION OF COMET 1887 IV.

PRESENTED TO THE FACULTY OF THE UNIVERSITY OF VIRGINIA ON APPLYING FOR THE DEGREE OF DOCTOR OF SCIENCE,

BY

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OF VIRGINIA.

FROM THE

ASTRONOMICAL JOURNAL.

Nos. 174–5.

DEFINITIVE DETERMINATION OF THE ORBIT OF COMET 1887 IV,

BY FRANK MULLER.

This comet was discovered by Mr. E. E. BARNARD at the observatory of Vanderbilt University, Nashville, Tenn., on May 12. It was then 0′.5 in diameter, with a stellar nucleus of the 11–12 magnitude; about perihelion it was of the 9–10 magnitude, with a tail 2′ long; soon after it became diffuse and elongated in the direction north and south, and was last seen by Mr. BARNARD on August 11, when its theoretical relative brightness was 0.3.

1. *Preliminary elements, perturbations, and ephemeris.* — Several sets of elements were published, not resting however upon sufficient data to indicate any deviation from a parabolic path. Finally, Mr. CHANDLER (*Astronomical Journal*, No. 160) noted that the observations could not be satisfied by parabolic elements. From normal places for May 14, June 12, and July 12, he computed the following elements, which represent the observations closely, and are practically definitive:

$$\begin{aligned} T &= \text{June } 16.66108 \text{ Greenwich M.T.} \\ \omega &= 15^\circ\ 8'\ 3''.7 \\ \Omega &= 245\ 13\ 16\ .8 \\ i &= 17\ 32\ 53\ .4 \end{aligned} \left.\vphantom{\begin{aligned}a\\b\\c\end{aligned}}\right\} 1887.0$$

$$\begin{aligned} \log q &= 0.1441634 \\ \log a &= 2.5009248 \\ e &= 0.9956014 \end{aligned}$$

Upon these elements I have based the ephemeris for the preparation of the normal places. That the differences between the ephemeris and observation might contain only the errors of observation, the perturbations were computed and applied to the ephemeris. All the planets from *Mercury* to *Saturn* were considered; the disturbances were small, and were chiefly caused by *Jupiter*, and by the *Earth*, with which the comet was nearly in conjunction during the whole apparition. The perturbations of the rectangular ecliptic coordinates were computed for every eight days, and the corresponding changes in right-ascension and declination were as follows:

1887 Gr. M.T.	Δx	Δy	Δz	$\Delta\alpha$ ″	$\Delta\delta$ ″
May 10.0	—242	—73	— 5	—6.44	+3.49
18.0	167	49	6	5.17	1.98
26.0	—106	—31	— 5	—3.72	+0.81
June 3.0	— 59	—17	— 3	—2.27	+0.14
11.0	26	8	2	1.06	—0.08
19.0	7	2	1	0.27	0.05
27.0	0	0	0	0.00	0.00
July 5.0	6	2	1	0.25	0.07
13.0	25	9	2	0.94	0.27
21.0	57	20	5	1.96	0.56
29.0	99	36	9	3.17	0.89
Aug. 6.0	153	57	15	4.48	1.21
14.0	—216	—84	—21	—5.78	—1.52

To avoid introducing any irregularity in the interpolation of the ephemeris, $\Delta\alpha$ and $\Delta\delta$ were separately obtained for every day. The masses and places of the disturbing planets were taken from the Berlin *Jahrbuch.*

The reduction to apparent place was computed, by means of the independent star-numbers of the *American Nautical Almanac*, for every four days. By interpolation this correction also was obtained for every day.

These corrections being applied, the following is the resulting ephemeris for Greenwich mean noon and midnight of each day:

1887	α h m s	δ ° ′ ″	log Δ
May 12.0	15 9 40.94	—30 56 47.5	9.6845
12.5	10 27.95	30 41 52.6	
13.0	11 15.34	30 26 40.8	9.6790
13.5	12 3.12	30 11 11.9	
14.0	12 51.30	29 55 26.1	9.6737
14.5	13 39.86	29 39 23.4	
15.0	14 28.82	29 23 3.7	9.6685
15.5	15 18.18	29 6 27.3	
16.0	16 7.94	28 49 34.2	9.6634
16.5	16 58.09	28 32 24.4	
17.0	17 48.64	28 14 58.0	9.6585
17.5	18 39.58	27 57 15.3	
18.0	19 30.93	27 39 16.4	9.6537
18.5	20 22.67	27 21 1.3	
19.0	21 14.82	27 2 30.3	9.6491
19.5	22 7.36	26 43 43.7	
20.0	23 0.30	26 24 41.5	9.6447
20.5	23 53.66	25 5 24.0	
21.0	24 47.41	25 45 51,5	9.6404
21.5	15 25 41.56	—25 26 4.2	

1887		α	δ	log Δ
		h m s	° ′ ″	
May	22.0	15 26 36.12	—25 6 2.5	9.6363
	22.5	27 31.08	24 45 46.6	
	23.0	28 26.44	24 25 16.8	9.6324
	23.5	29 22.20	24 4 33.5	
	24.0	30 18.36	23 43 37.0	9.6287
	24.5	31 14.90	23 22 27.7	
	25.0	32 11.84	23 1 5.9	9.6252
	25.5	33 9.17	22 39 32.1	
	26.0	34 6.88	22 17 46.7	9.6219
	26.5	35 5.00	21 55 50.1	
	27.0	36 3.48	21 33 42.8	9.6189
	27.5	37 2.35	21 11 25.2	
	28.0	38 1.58	20 48 57.8	9.6161
	28.5	39 1.17	20 26 21.1	
	29.0	40 1.12	20 3 35.6	9.6134
	29.5	41 1.43	19 40 41.8	
	30.0	42 2.08	19 17 40.2	9.6111
	30.5	43 3.08	18 54 31.3	
	31.0	44 4.41	18 31 15.8	9.6090
	31.5	45 6.07	18 7 54.2	
June	1.0	46 8.04	17 44 27.0	9.6071
	1.5	47 10.34	17 20 54.8	
	2.0	48 12.93	16 57 18.2	9.6055
	2.5	49 15.82	16 33 37.8	
	3.0	50 19.00	16 9 54.2	9.6041
	3.5	51 22.47	15 46 8.0	
	4.0	52 26.20	15 22 19.8	9.6030
	4.5	53 30.20	14 58 30.1	
	5.0	54 34.46	14 34 39.7	9.6021
	5.5	55 38.95	13 10 49.1	
	6.0	56 43.67	13 46 59.0	9.6015
	6.5	57 48.62	13 23 9.9	
	7.0	58 53.78	12 59 22.4	9.6011
	7.5	15 59 59.15	12 35 37.3	
	8.0	16 1 4.71	12 11 55.0	9.6010
	8.5	2 10.46	11 48 16.3	
	9.0	3 16.39	11 24 41.6	9.6012
	9.5	4 22.48	11 1 11.6	
	10.0	5 28.74	10 37 47.0	9.6016
	10.5	6 35.14	10 14 28.2	
	11.0	7 41.68	9 51 15.8	9.6023
	11.5	8 48.35	9 28 10.5	
	12.0	9 55.15	9 5 12.8	9.6032
	12.5	11 2.06	8 42 23.2	
	13.0	12 9.08	8 19 42.3	9.6043
	13.5	13 16.20	7 57 10.5	
	14.0	14 23.43	7 34 48.5	9.6057
	14.5	15 30.73	7 12 36.7	
	15.0	16 38.12	6 50 35.5	9.6074
	15.5	17 45.58	6 28 45.6	
	16.0	18 53.12	6 7 7.2	9.6092
	16.5	20 0.71	5 45 40.9	
	17.0	21 8.35	5 24 27.0	9.6113
	17.5	22 16.04	5 3 26.1	
	18.0	23 23.78	4 42 38.5	9.6136
	18.5	24 31.54	4 22 4.6	
	19.0	25 39.34	4 1 44.7	9.6161
	19.5	26 47.15	3 41 39.2	
	20.0	27 54.98	3 21 48.3	9.6188
	20.5	29 2.82	3 2 12.5	
	21.0	30 10.67	2 42 51.9	9.6217
	21.5	31 18.52	2 23 46.9	
	22.0	32 26.37	2 4 57.6	9.6249
	22.5	16 33 34.20	— 1 46 24.4	
June	23.0	16 34 42.03	--1 28 7.3	9.6281
	23.5	35 49.83	1 10 6.6	
	24.0	36 57.61	0 52 22.6	9.6316
	24.5	38 5.35	0 34 55.2	
	25.0	39 13.06	0 17 44.6	9.6352
	25.5	40 20.74	—0 0 51.1	
	26.0	41 28.36	+0 15 45.4	9.6389
	26.5	42 35.93	0 32 4.6	
	27.0	43 43.45	0 48 6.7	9.6428
	27.5	44 50.91	1 3 51.4	
	28.0	45 58.30	1 19 18.8	9.6469
	28.5	47 5.62	1 34 28.8	
	29.0	48 12.87	1 49 21.4	9.6511
	29.5	49 20.03	2 3 56.6	
	30.0	50 27.12	2 18 14.3	9.6554
	30.5	51 34.11	2 32 14.7	
July	1.0	52 41.01	2 45 57.8	9.6598
	1.5	53 47.81	2 59 23.5	
	2.0	54 54.51	3 12 32.0	9.6644
	2.5	56 1.10	3 25 23.2	
	3.0	57 7.58	3 37 57.3	9.6690
	3.5	58 13.94	3 50 14.4	
	4.0	16 59 20.18	4 2 14.4	9.6738
	4.5	17 0 26.31	4 13 57.6	
	5.0	1 32.30	4 25 24.0	9.6786
	5.5	2 38.16	4 36 33.7	
	6.0	3 43.89	4 47 26.9	9.6835
	6.5	4 49.49	4 58 3.5	
	7.0	5 54.94	5 8 23.9	9.6885
	7.5	7 0.26	5 18 28.0	
	8.0	8 5.43	5 28 16.1	9.6936
	8.5	9 10.45	5 37 48.3	
	9.0	10 15.33	5 47 4.6	5.6987
	9.5	11 20.06	5 56 5.3	
	10.0	12 24.64	6 4 50.5	9.7039
	10.5	13 29.08	6 13 20.4	
	11.0	14 33.36	6 21 35.1	9.7092
	11.5	15 37.49	6 29 34.7	
	12.0	16 41.47	6 37 19.5	9.7145
	12.5	17 45.31	6 44 49.6	
	13.0	18 48.99	6 52 5.1	9.7199
	13.5	19 52.53	6 59 6.3	
	14.0	20 55.92	7 5 53.3	9.7254
	14.5	21 59.16	7 12 26.2	
	15.0	23 2.25	7 18 45.4	9.7308
	15.5	24 5.20	7 24 50.9	
	16.0	25 8.00	7 30 42.8	9.7363
	16.5	26 10.66	7 36 21.6	
	17.0	27 13.18	7 41 47.1	9.7418
	17.5	28 15.56	7 46 59.8	
	18.0	29 17.79	7 51 59.7	9.7473
	18.5	30 19.89	7 56 47.1	
	19.0	31 21.84	8 1 22.1	9.7530
	19.5	32 23.67	8 5 45.0	
	20.0	33 25.36	8 9 55.9	9.7586
	20.5	34 26.92	8 13 55.0	
	21.0	35 28.35	8 17 42.6	9.7643
	21.5	36 29.65	8 21 18.8	
	22.0	37 30.82	8 24 43.8	9.7700
	22.5	38 31.86	8 27 57.9	
	23.0	39 32.78	8 31 1.2	9.7757
	23.5	40 33.58	8 33 53.9	
	24.0	41 34.26	8 36 36.2	9.7814
	24.5	17 42 34.81	+8 39 8.3	

1887		α	δ	log Δ
		h m s	° ′ ″	
July	25.0	17 43 35.24	+8 41 30.4	9.7872
	25.5	44 35.56	8 43 42.8	
	26.0	45 35.76	8 45 45.4	9.7929
	26.5	46 35.84	8 47 38.7	
	27.0	47 35.81	8 49 22.7	9.7987
	27.5	48 35.66	8 50 57.7	
	28.0	49 35.40	8 52 23.8	9.8044
	28.5	50 35.02	8 53 41.2	
	29.0	51 34.52	8 54 50.0	9.8103
	29.5	52 33.92	8 55 50.6	
	30.0	53 33.19	8 56 43.0	9.8161
	30.5	54 32.36	8 57 27.4	
	31.0	55 31.41	8 58 4.0	9.8219
	31.5	56 30.35	8 58 33.0	
Aug.	1.0	57 29.18	8 58 54.4	9.8277
	1.5	58 27.89	8 59 8.6	
	2.0	17 59 26.50	8 59 15.7	9.8335
	2.5	18 0 25.00	8 59 15.8	
	3.0	1 23.38	8 59 9.0	9.8393
	3.5	2 21.66	8 58 55.6	
	4.0	3 19.83	8 58 35.7	9.8451
	4.5	4 17.90	8 58 9.4	
	5.0	5 15.86	8 57 36.8	9.8509
	5.5	6 13.71	8 56 58.2	
	6.0	7 11.46	8 56 13.6	9.8567
	6.5	8 9.11	8 55 23.3	
	7.0	9 6.65	8 54 27.3	9.8625
	7.5	10 4.10	8 53 25.8	
	8.0	11 1.44	8 52 18.9	9.8684
	8.5	11 58.70	8 51 6.8	
	9.0	12 55.85	8 49 49.5	9.8742
	9.5	13 52.90	8 48 27.3	
	10.0	14 49.87	8 47 0.2	9.8800
	10.5	15 46.74	8 45 28.5	
	11.0	16 43.52	8 43 52.1	9.8858
	11.5	17 40.21	8 42 11.2	
	12.0	18 18 36.82	+8 40 26.0	9.8916

Comparison of part of this ephemeris with an ephemeris computed by Mr. Chandler showed small differences, which Mr. Chandler explained by stating that in the reduction to apparent place he had used the *British Nautical Almanac*, in which nutation-terms of short period are neglected.

2. *Comparison-Stars.*—The stars used lie between 30° south declination, and 8° north declination. The positions of all stars brighter than the ninth magnitude, between —2° and +5°, have been kindly furnished by Prof. Kortazzi of Nicolajew, and Prof. Boss of Albany, from their as yet unpublished A.G. Zone observations. The positions of the stars north of +5° had not been reduced, but I am indebted to Prof. Bruns of Leipsic, for the apparent places of these stars. With a few exceptions, all the positions from the A.G. zones are the means of two or more observations. I am also indebted to Mr. Skinner of the U.S. Naval Observatory for places from various catalogues.

South of —2°, the southern limit of the *Astronomische Gesellschaft* zones, I have collected nearly all the observations of the stars used; this appears desirable for the detection of proper motion, and the elimination of accidental errors. While a complete discussion is not warranted, some system is necessary in combining these miscellaneous observations. The weights given below were assigned, taking into consideration the accuracy of observation and the chance of the effect of a proper motion too small to be detected. These weights were used when the places depended on one or two observations; for three to six observations the weights were increased by one-half; for seven or more observations they were doubled, the systematic error of the catalogues being then probably in excess of the accidental errors.

For the sake of brevity, I have given only the adopted mean place and the authorities upon which it rests. To indicate the various catalogues the following abbreviations are used:

A. = Oeltzen's Argelander. Weight $\frac{1}{4}$.

A.G. = *Astronomische Gesellschaft* zones. Abbreviations are attached to show the places of observations; Albany, Leipsic and Nicolajew. Weight $\frac{3}{2}$.

A N. = Star-places in *Astronomische Nachrichten*.

Ar. = Second Armagh Catalogue. Weight $\frac{1}{2}$.

B = Bonn Observations, Vol. VI. Weight $\frac{1}{4}$.

Br. = Brisbane, Observations at Paramatta. Weight $\frac{1}{8}$.

C, CZ = Argentine General or Zone Catalogue. Weight 1.

Cin. = Cincinnati Zone Catalogue. Weight $\frac{1}{2}$.

Cp. = Catalogues, for the epochs 1840, '50, '60, '80, of stars observed at the Cape of Good Hope. 1840–60, weight $\frac{1}{2}$; 1880, weight 1.

D. = Observations made at Dunsink, 1885. Weight 1.

G. = Göttingen. Weight $\frac{1}{2}$.

Gr. = Greenwich. Weight $\frac{1}{2}$.

L. = Lamont. Weight $\frac{1}{4}$.

P. = Pulkowa. Weight $\frac{1}{2}$.

R. = Radcliffe, 1884–85–86. Weight 1.

Si. = Santini. Weight $\frac{1}{4}$.

Sj. = Schjellerup. Weight $\frac{3}{8}$.

T. = Tacchini (Washburn Obs. publications). Weight $\frac{1}{4}$.

W.Z. = Washington Zones. Weight $\frac{1}{8}$.

Y. = Yarnall. Weight $\frac{1}{2}$.

Comp. indicates that the places were obtained by a comparison with a known star.

The Washington zones were only used when no other authority was available.

Mean Places for 1887.0 of the Comparison-Stars.

No.	α	δ	Authorities.	No.	α	δ	Authorities.
	h m s	° ′ ″			h m s	° ′ ″	
1	15 10 57.34	—29 43 55.8	A, C, Cp, '40, '50, '60, '80, Y	4	15 12 30.07	—28 33 37.8	A, C
2	11 3.17	30 3 38.6	A, CZ, Y	5	12 51.25	29 29 22.9	CZ
3	15 11 45.84	—30 47 40.8	A, C, Cp '40, '80	6	15 13 4.02	—29 41 39.4	A, CZ

No.	α	δ	Authorities
	h m s	° ′ ″	
7	15 13 43.31	—27 52 33.5	A, B, C, Cp '80
8	14 34.31	29 7 8.1	CZ
9	15 53.22	28 56 8.4	A, Br, Cp '80, CZ, Y
10	16 3.36	28 46 4.3	A, CZ
11	20 0.26	27 34 34.0	A, C, Y
12	21 20.73	26 44 23.5	C
13	21 22.80	27 13 55.5	CZ
14	21 32.51	26 43 27.7	C
15	21 44.37	26 38 0.3	CZ
16	21 58.42	26 7 11.4	CZ
17	22 40.42	26 12 48.1	A, CZ
17^1	24 15.11	25 35 32.4	Comp
17^2	25 15.94	25 30 50.2	Comp
18	26 23.39	25 24 56.5	A, C, Cp '80, WZ, Y
19	26 28.38	24 6 21.5	A, Cp '80, Y
20	27 12.20	24 43 40.3	A, Br, C, Cp '80 Gr '60, Y
21	28 23.36	24 43 31.1	A, C, Cp '80, Y
22	29 27.78	24 14 42.3	Comp
23	29 54.76	28 37 8.1	B, C, T
24	30 8.12	24 12 40.3	CZ
25	30 32.14	23 16 37.0	A, AN, CZ
26	30 32.92	21 10 54.0	Paris Mer Circle
27	30 36.63	24 2 3.4	A, CZ
28	30 55.03	21 45 34.1	C, D, Y
29	32 6.17	22 40 40.5	A, C, T, Y
30	32 25.3	22 6 12.1	WZ
31	32 42.54	22 46 46.2	A, AN, C, Y
32	32 51.00	23 25 50.6	C
33	32 57.90	23 21 13.9	C
34	33 5.74	22 31 22.0	Y
35	33 36.09	23 26 59.1	C, Cp '40, '50, '60, '80, Gr '72, R
36	33 44.76	22 7 5.6	Comp
37	34 8.62	21 14 11.5	B
38	35 13.61	22 54 25.2	A, B, C, T
39	35 15.68	23 56 7.1	A, C, LL, WZ
40	36 45.10	20 45 14.3	A, WZ
41	37 42.07	22 1 4.0	A, WZ
42	38 5.40	21 9 39.6	Comp
43	40 28.87	18 46 48.8	A
44	40 47.39	20 6 50.4	AN, B. Cin
45	41 18.93	21 17 6.7	Paris Mer Circle
46	42 7.82	18 52 0.6	A
47	43 5.51	20 25 50.6	A, AN, B, Cin
48	45 7.86	18 35 44.9	A, Y
49	45 47.33	18 5 46.8	A
49^1	46 46.47	19 47 41.9	C, Y
50	48 28.55	19 2 53.3	A, CZ, R, Y
51	56 13.19	13 29 47.6	B
52	15 58 9.28	11 3 36.0	AN, C, R, Sj, W, Y
53	16 0 46.38	11 59 40.5	Gr '40, W
54	1 2.65	12 49 46.0	Sj
55	1 19.87	12 26 25.9	C, R
56	1 30.49	11 36 50.8	W
57	3 6.14	11 15 4.6	Comp
58	3 6.59	12 4 31.9	AN, Sj, W
59	3 38.09	10 49 57.6	Si, W
59^1	4 38.89	11 46 13.2	Sj
59^2	5 18.22	10 58 4.5	Comp
59^3	5 45.18	10 19 41.3	B
60	5 49.49	9 46 13.3	AN, Sj, W
61	6 7.69	10 54 26.0	Si, W
62	16 7 35.11	—10 17 13.4	W
63	16 8 4.18	—10 7 35.9	AN, W
64	8 20.70	10 22 21.8	W, Y
65	8 37.90	9 26 55.5	L, Sj
66	9 28.64	8 4 9.6	P, Sj
67	11 48.66	7 7 10.4	W
68	11 51.75	8 0 12.7	W
69	12 44.00	8 47 32.7	Sj
70	13 6.45	6 35 51.1	W
71	16 7.66	7 21 35.2	Comp
72	16 25.24	6 35 47.2	W, Sj
73	16 55.00	6 56 30.7	LL
74	18 12.54	6 9 12.6	W
75	18 19.29	6 27 43.0	Harrow Mer Circle
76	18 46.97	7 21 41.4	Sj, W
77	18 54.40	5 47 29.7	Comp
78	19 28.79	5 50 9.6	L
79	19 37.28	5 38 12.5	LL
80	19 48.78	5 50 9.5	L
81	20 17.93	4 25 6.1	Sj
82	22 48.21	5 11 38.2	Sj, W
83	23 9.24	5 12 3.1	Sj, W
84	23 37.45	5 2 53.0	AN
85	23 59.41	2 27 52.3	Sj, W
86	24 25.78	5 50 48.5	AN, Sj, W
87	24 44.45	4 25 2.6	Comp
88	26 13.57	3 43 20.5	Comp
88^1	26 16.50	4 15 12.7	Sj
88^2	27 38.61	3 8 29.8	Comp
89	28 1.92	3 33 3.1	AN, L
90	28 28.62	3 46 36.4	L
91	29 58.47	2 57 29.2	Comp
92	30 25.09	2 4 56.1	C, D
93	31 7.00	2 26 3.4	Sj
94	31 26.36	2 48 51.0	Sj, W
95	32 26.17	2 12 10.0	Sj, W
96	32 42.68	1 49 54.7	L
97	32 43.52	1 0 16.3	G
98	32 50.92	0 57 29.0	AG Nic
99	34 35.87	1 37 10.3	AG Nic
100	34 58.26	1 46 39.8	Sj, W
101	35 55.54	1 55 36.5	AG Nic
102	36 6.27	0 28 36.4	W
103	36 36.15	1 14 51.2	Comp
104	36 41.57	— 1 53 56.6	AG Nic
105	37 42.62	+ 0 8 40.1	B
106	37 52.94	— 0 34 14.6	G, L
107	37 56.65	1 23 46.2	B
108	38 26.09	0 1 4.7	Comp
109	39 1.00	0 7 43.4	AG Nic
110	39 56.96	— 0 33 16.6	AG Nic
111	41 34.73	+ 0 0 14.3	L
112	43 40.53	1 5 24.7	L
113	44 3.13	2 6 38.5	AG Alb
114	44 52.55	0 30 56.0	B
115	45 30.02	1 35 9.7	AG Alb
116	45 40.97	1 24 33.1	$\frac{1}{3}$ (2 Gl+Sj)
117	47 40.13	1 32 10.4	AG Alb
118	48 26.83	2 2 28.6	L
119	50 22.22	1 36 7.4	AG Alb
120	51 30.66	3 20 21.5	AG Alb
121	52 19.85	2 31 2.3	W
122	16 54 5.56	+2 31 3.7	AG Alb

No.	α	δ	Authorities
	h m s	° ′ ″	
123	16 58 57.16	+2 55 27.4	AG Alb
124	17 4 30.38	5 2 48.3	AG Leip
125	5 7.35	5 31 19.2	"
126	7 2.80	5 2 43.4	"
127	7 18.84	6 11 1.4	"
128	8 11.42	5 56 32.6	"
129	8 47.07	5 35 2.0	Comp
130	10 55.07	5 15 15.5	AG Leip
131	11 21.54	5 58 23.9	Comp
132	13 21.41	6 12 17.2	AG Leip
133	14 18.38	6 40 4.2	"
134	15 18.14	6 32 59.1	"
135	15 21.47	6·48 24.4	"
136	15 54.89	6 32 35.2	L, W
137	16 48.80	6 46 8.7	AG Leip
138	17 50.19	6 43 46.0	Comp
139	17 54.30	7 11 59.9	B
140	18 55.62	6 37 26.7	AG Leip
141	19 44.46	6 31 54.8	"
142	20 2.40	6 45 49.0	"
143	20 51.72	7 41 42.6	"
144	23 4.19	7 21 45.7	"
145	17 24 8.62	+7 36 36.2	"
145[1]	17 25 8.04	+6 51 3.0	B
146	26 36.76	7 36 0.6	AG Leip
147	28 4.41	7 15 29.3	"
148	28 27.14	8 11 5.0	"
149	34 29.64	7 51 50.0	"
150	35 12.11	8 32 10.7	"
151	36 25.76	8 16 31.4	"
152	37 32.46	8 6 49.8	½ (W+LL)
153	38 6.16	8 29 15.4	B
154	38 20.62	8 39 59.5	AG Leip
155	42 8.30	8 35 22.7	"
156	45 39.37	8 33 41.9	"
157	47 29.06	8 50 7.2	B
158	47 30.14	8 43 5.4	B
159	17 49 59.13	8 55 15.5	A.G. Leip
160	18 8 29.90	8 56 44.1	W
161	8 55.59	8 51 4.3	A.G. Leip
162	9 30.02	8 56 43.1	"
163	9 45.65	8 45 20.4	Sj, W
164	12 41.25	8 47 39.4	Comp
165	15 36.34	8 34 40.9	A.G. Leip
166	18 17 17.22	+8 43 45.4	"

REMARKS.

3. The Cape Catalogue of 1880 gives a proper motion of $+0^s.010$ deduced from comparison with the Catalogue of 1840, but the other observations do not sustain the determination.

7. A provisional proper motion of $-0''.08$ in δ was used.

18. Prof. Kortazzi used a proper motion for this star and the preceding one determined by comparison with Lacaille; Lacaille not being available I have used a provisional proper motion of $+0^s.010$ in α.

20. The S.P.D. of Brisbane 5382 requires a correction of $-5'$.

28. The declination of Yarnall 6425 is incorrect. Prof. Frisby has kindly given the correct declination for 1860, $-21° 39' 9''.6$.

29. Lalande not being available, a provisional proper motion of $+0^s.005$ in α was used.

39. Prof. Boss gives the proper motion as $-0^s.009$ and $-0''.50$ (*A.J.* 157).

44. A proper motion, given in the Cincinnati Zone Catalogue, of $-0^s.0075$ and $-0''.111$ was used.

55. There appears to be a small negative proper motion in right ascension.

66. The proper motion of $+0^s.0112$ and $-0''514$, given in the Pulkowa Catalogue, was used.

92. The right-ascensions given in LL, W, L, Sj, C, D, and A.G. Nic. are well satisfied with a proper motion of $+0^s.028$. The declinations are very discordant but are best satisfied with a proper motion of $-0''.09$.

3. *Observations of the Comet.* — On collecting all the observations published, 313 were found available. The right-ascensions and declinations given below are the observed values corrected for parallax and for the adopted places of the comparison-stars; $\Delta\alpha$ and $\Delta\delta$ are the differences (O—C) between these values and the values given by the ephemeris. The observations are arranged alphabetically with reference to the place of observation. The name of the observer, the aperture of the instrument used, and the place of the publication of the observations, are given. In many cases the character of the instrument used was not stated; in these cases it has been assumed in accordance with the known equipment of the observatory in question. *R.* denotes that a ring-micrometer, and *Mer.* that a meridian circle, was used, in other cases a filar-micrometer was employed.

Gr. M.T.	α	δ	Δα	Δδ	*
Albany. Boss. 13 in. *A.J.* 157.					
May	h m s	° ′ ″	s	′	
13.67719	15 12 20.43	—30 5 44.0	+0.28	— 5.3	2
15.71082	15 38.40	28 59 26.3	(—0.71	4.1)	9
18.72316	20 46.43	27 12 52.6	+0.54	— 5.2	13
23.71682	29 46.85	23 55 30.0	+0.35	+ 0.2	27
23.75353	15 29 50.83	—23 53 58.9	+0.21	— 0.9	38
May 15. Observation doubtful.					
Algiers. Rambaud. 50 cm. *A.N.* 2788; *B.A.* Oct., Nov.					
May					
16.46698	15 16 55.30	—28 33 44.5	+0.53	—11.6	10
18.39274	15 20 12.44	—27 25 5.3	+0.81	— 7.8	11

Gr.M.T.	α	δ	Δα	Δδ	*
Algiers. Rambaud. *A.N.* 2788; *B.A.* Oct., Nov.					
May	h m s	° ′ s	s	″	
19.44698	15 22 2.87	—26 45 47.4	+1.11	— 3.5	14
20.37656	23 40.76	26 10 19.6	0.31	— 8.5	17
21.36892	25 27.82	25 31 16.7	.49	+ 0.1	18
23.37552	29 9.03	24 9 50.2	.74	— 8.0	24
24.37556	31 0.84	23 27 51.0	.05	6.2	23
25.41920	33 0.70	22 43 4.6	.83	2.6	37
26.40731	34 54.24	22 0 0.7	+0.06	5.7	40
28.40828	15 38 50.08	—20 30 36.3	—0.16	— 6.3	39

Gr. M.T.	α	δ	Δα	Δδ	*

Algiers. RAMBAUD. *A.N.* 2788; *B.A.* Oct., Nov.

Gr. M.T.	α	δ	Δα	Δδ	*
	h m s	° ′ ″	s	″	
Aug. 8.39656	18 11 46.86	+ 8 51 26.9	0.00	+ 4.8	163
9.35318	18 13 35.23	+ 8 48 46.2	(—0.93	— 5.8)	164

May 16–24. Signs of parallax-factors for α changed.
May 26. Sign of Δδ changed.

Algiers. TRÉPIED. 50 cm. *A.N.* 2788; *B.A.*, Oct., Nov.

Gr. M.T.	α	δ	Δα	Δδ	*
May 16.42894	15 16 51.62	—28 35 11.2	(—0.78	—19.5)	10
18.36561	20 9.27	27 26 10.4	+0.56	13.0	11
19.41858	21 59.46	26 46 56.2	.68	8.0	14
20.36493	22 39.54	26 10 41.2	.34	3.1	17
21.36002	25 26.97	25 31 44.0	.61	5.9	18
23.35992	29 7.13	24 10 30.6	.59	7.4	24
24.36413	30 59.67	23 28 23.5	0.17	9.6	23
25.40290	32 59.30	22 44 52.0	1.30	7.7	37
28.32227	15 38 47.12	—20 31 48.5	+0.01	— 7.2	39
Aug. 8.37098	18 11 43.76	+ 8 51 18.2	—0.18	— 7.7	163
9.36638	18 13 36.69	+ 7 48 41.9	(—0.98	— 7.9)	164

May 16–24. Signs of parallax-factors for δ changed.

Algiers. SY. 50 cm. *B.A.*, Nov.

Gr. M.T.	α	δ	Δα	Δδ	*
Aug. 9.38796	18 13 39.17	+ 8 48 37.5	(—0.96	— 8.7)	164

Berlin. BATTERMANN. 6f refr. *A.N.* 2808.

Gr. M.T.	α	δ	Δα	Δδ	*
June 16.45728	16 19 55.47	— 5 47 44.1	+0.54	—13.8	80
24.47733	38 4.18	— 0 35 24.9	(1.90	+17.4)	106
26.43876	16 42 29.45	+ 0 29 55.0	+1.79	—10.6	114

Berlin. KNORRE. 9 in.? *A.N.* 2787, 2826.

Gr. M.T.	α	δ	Δα	Δδ	*
May 23.45273	15 29 17.47	—24 6 36.8	+0.56	— 5.2	27
June 24.43564	16 37 56.84	— 0 37 16.6	+0.20	— 7.6	106

Besançon. GRUEY. 8 in. *C.R.* XV. 13.

Gr. M.T.	α	δ	Δα	Δδ	*
June 13.46540	16 13 12.26	— 7 59 6.1	+0.30	—22.3	68
14.47580	15 28.70	7 13 37.1	1.23	+ 3.8	71
16.45435	19 54.78	5 47 42.6	0.25	— 4.8	80
16.49858	20 0.65	5 46 0.7	.14	16.2	80
17.41889	16 22 5.88	— 5 6 57.6	+0.82	— 7.8	83
July 8.39210	17 8 56.88	+ 5 35 51.2	+0.45	+ 6.2	129
8.41500	8 59.42	5 36 15.4	.01	+ 4.1	129
12.40788	17 34.08	6 43 21.7	.52	—17.7	140
12.48854	17 44.27	6 44 30.9	.43	17.6	140
16.41407	26 0.08	7 35 23.9	+ .17	0.4	146
23.46638	17 40 28.71	+ 8 33 35.9	—0.79	— 6.7	155

July 16. Δ N.P.D. incorrectly added.

Besançon. GUILLIN. 7 in. Mer. *C.R.* XV. 13.

Gr. M.T.	α	δ	Δα	Δδ	*
June 17.42450	16 22 5.77	— 5 6 30.6	+0.05	+ 5.1	—
18.42332	24 20.87	4 25 32.6	.28	—19.7	—
20.42102	28 51.81	3 5 40.9	.30	23.7	—
21.41984	31 7.50	2 27 13.1	+ .14	—23.9	—
22.41866	16 33 23.30	— 1 48 57.1	(—0.13	+27.3)	—

Besançon. HERIQUE. 8 in. *C.R.* XV. 13.

Gr. M.T.	α	δ	Δα	Δδ	*
	h m s	° ′ ″	s	″	
June 18.45995	16 24 26.64	— 4 23 52.6	+0.53	— 9.7	88[1]
20.44311	28 55.35	3 4 39.8	.25	—15.3	91
21.50811	31 20.45	2 23 28.2	.83	+ 0.2	95
22.45071	33 28.32	1 48 21.9	.80	— 8.5	100
23.47095	35 46.57	1 11 18.2	.68	9.0	103
24.42892	16 37 56.13	— 0 37 30.9	+0.41	— 7.9	110
July 16.45592	17 26 5.88	+ 7 35 47.2	+0.74	— 5.0	146

July 16, Δ N.P.D. incorrectly added.

Bordeaux. COURTY. 14 in. *A.N.* 2793.

Gr. M.T.	α	δ	Δα	Δδ	*
May 27.40909	15 36 52.24	—21 15 31.7	0.00	— 2.5	37
June 9.41395	16 4 11.65	—11 5 21.0	+0.55	— 7.1	52
10.42858	6 26.09	10 17 46.6	.45	+ 1.1	64
16.39597	19 46.89	5 50 16.1	+ .25	— 8.6	86
17.40344	22 2.26	5 7 32.1	— .71	3.5	82
17.40344	22 3.81	5 7 43.9	+ .84	15.3	84
21.40736	16 31 6.25	— 2 27 26.8	+0.30	— 8.9	85

Bordeaux. FLAMME. 14 in. *A.N.* 2793, 2803.

Gr. M.T.	α	δ	Δα	Δδ	*
May 27.47768	15 37 0.26	—21 12 26.0	+0.55	— 0.8	37
June 13.44806	16 13 9.46	— 7 59 32.4	+0.23	— 1.9	66
28.49344	16 47 5.20	— 1 34 6.2	+0.46	—10.8	119
July 1.56054	16 53 56.30	— 3 0 59.2	+0.41	— 0.7	123
12.51014	17 17 46.89	6 45 2.9	.29	+ 4.4	133
22.47940	38 29.84	8 27 45.5	.49	— 4.6	150
27.48267	48 33.79	50 57.1	.20	+ 2.6	159
29.45557	17 52 28.80	— 55 53.9	+0.16	+ 8.4	159
Aug. 6.43196	18 7 1.49	— 55 41.7	+0.22	+11.2	160
8.42611	11 50.37	51 20.6	.13	2.8	161
10.43007	18 15 39.04	+ 8 45 49.2	+0.25	+ 7.6	166

July 29. Sign of Δ N.P.D. changed.

Bordeaux. RAYET. 14 in. *A.N.* 2793, 2803.

Gr. M.T.	α	δ	Δα	Δδ	*
May 22.42317	15 27 23.52	—24 49 4.0	+0.91	— 9.7	20
26.41277	15 34 56.54	—21 59 51.1	+1.72	—10.5	30
June 11.44261	16 8 40.77	— 9 32 6.9	(+0.08	—77.7)	65
12.40966	10 50.25	8 46 30.9	+ .29	0.9	69
14.43718	15 22.22	7 15 39.8	— .05	—16.4	67
15.42183	17 35.68	6 32 8.5	+ .65	+ 0.9	70
18.43440	24 23.04	4 24 51.4	+ .39	— 5.7	81
22.43296	33 24.70	1 49 8.2	— .41	15.5	104
29.46876	49 16.36	— 2 2 53.0	+ .52	9.4	113
30.42517	16 51 24.52	+ 2 30 2.0	+0.43	— 8.1	122
July 2.46214	16 55 56.48	+ 3 24 27.4	+0.42	+ 2.0	120
6.43414	17 4 47.14	4 57 23.6	.28	(43.0)	126
7.41786	6 49.86	5 16 50.5	.32	0.6	130
11.42414	15 28.16	6 28 28.1	.39	5.2	141
13.42092	19 40.19	6 58 10.6	.70	10.0	135
19.44571	32 17.45	8 5 19.1	.49	2.1	148
24.41942	17 42 25.30	+ 8 38 56.1	+0.24	+11.6	156

July 2. δ changed 10′.
July 7. α changed 1m.

Bothkamp. J. Lamp. 30 cm? *A.N.* 2792, 2797.

Gr. M.T.	α	δ	Δα	Δδ	*
	h m s	° ′ ″	s	″	
June 15.46852	16 17 42.19	— 6 30 11.4	+0.85	— 2.7	72
16.45355	19 55.82	5 48 53.6	.39	13.8	86
24.48831	38 4.53	— 0 35 29.1	.76	9.6	110
28.48334	16 47 3.62	+ 1 33 54.2	+0.24	— 4.6	117
July 25.43343	17 44 27.65	+ 8 43 28.5	+0.11	+ 2.8	158
25.45595	17 44 30.37	+ 8 43 32.6	+0.12	+ 1.1	158

Cambridge, Mass. Chandler. 6.5 in. *A.J.* 163.

Gr. M.T.	α	δ	Δα	Δδ	*
May 30.63543	15 43 20.46	—18 48 22.4	+0.80	— 8.4	46
30.65337	43 22.19	47 23.6	.33	+ 0.4	43
30.66104	15 43 22.90	—18 47 9.9	+0.10	— 7.4	48
July 12.58900	17 17 56.59	+ 6 46 1.8	—0.06	— 6.4	137
12.61558	17 18 1.18	+ 6 46 31.8	+1.14	+ 0.3	142

Cambridge, Mass. Wendell. 15 in. *A.N.* 2799.

Gr. M.T.	α	δ	Δα	Δδ	*
May 13.63318	15 12 16.26	—30 7 4.1	+0.44	— 2.4	2
14.63784	13 53.50	29 34 59.8	+ .28	3.8	5
19.66315	22 24.49	26 37 35.6	— .10	3.0	14
25.63713	33 25.23	22 33 36.3	+ .27	1.0	29
30.60634	15 43 15.89	—18 49 37.3	—0.21	— 2.2	46
June 7.60177	16 0 12.47	—12 30 53.5	—0.01	— 7.0	55
8.59124	2 23.15	11 43 55.9	+ .67	+ 1.9	62
13.69348	13 42.35	7 48 32.2	+ .15	—12.2	68
14.69343	15 45.10	7 7 52.7	— .46	7.9	73
15.60010	17 58.95	— 6 24 25.8	0.15	1.2	72
25.64926	16 40 39.69	+ 0 3 39.9	(—1.23	—28.3)	105

Cape of Good Hope. Finlay. 7 in. *A.N.* 2805.

Gr. M.T.	α	δ	Δα	Δδ	*
May 19.56766	15 22 15.01	—26 40 14.9	+0.51	— 4.9	12
21.28890	25 29.50	25 34 32.8	(9.85	5.5)	17[1]
21.29450	25 30.10		(10.84)		17[2]
23.24944	28 54.54	24 15 3.2	0.33	5.0	22
24.27179	30 49.43	23 32 13.8	+0.39	5.2	23
27.60281	15 37 12.37	—21 7 1.1	(—2.13	—12.2)	42
June 8.21528	16 1 33.66	—12 1 55.9	+0.66	—13.3	53
9.23044	3 47.22	11 13 57.2	.39	6.1	57
17.50669	16 22 17.86	— 5 3 18.4	+0.91	— 9.0	84

Signs of parallax-factors for α changed.
Right-ascensions given half weight; declinations, double weight.

Dresden. Engelhardt. 30 cm. *A.N.* 2786, 2788, 2792, 2797

Gr. M.T.	α	δ	Δα	Δδ	*
May 19.44089	15 22 2.56	—26 45 46.4	+1.43	+11.2	12
22.42624	15 27 23.86	—24 48 50.9	+0.91	— 4.1	21
June 13.42811	16 13 7.00	— 8 0 48.5	+0.45	—24.2	66
July 16.41721	17 26 0.29	+ 7 35 24.6	—0.01	— 1.8	145

Geneva. Kammermann. 10 in. *A.N.* 2823.

Gr. M.T.	α	δ	Δα	Δδ	*
May 19.41078	15 21 58.26	—26 47 5.4	+0.31	+ 0.4	12
June 6.38892	15 57 34.81	—13 28 31.0	+0.64	— 3.8	51
10.40752	16 6 23.33	10 18 52.0	.49	— 5.6	59[3]
12.38933	10 47.46	8 47 24.9	.22	+ 0.7	69
13.38213	13 1.07	8 2 35.6	0.70	— 7.3	68
14.41456	19 15 20.40	— 7 16 28.4	+1.17	— 4.9	71

Geneva. Kammermann. 10 in. *A.N.* 2823.

Gr. M.T.	α	δ	Δα	Δδ	*
	h m s	° ′ ″	s	″	
June 15.40781	16 17 33.50	— 6 32 51.7	+0.36	— 5.5	72
16.40743	19 48.56	5 49 48.8	.37	10.7	78
17.41032	22 3.96	5 7 17.0	.06	5.7	82
21.40737	31 6.51	2 27 35.9	.56	18.0	93
24.38109	37 49.49	— 0 39 5.5	.25	2.7	106
27.39468	44 36.77	+ 1 0 25.2	+ .07	8.6	112
29.39141	49 5.26	2 0 45.4	— .19	2.6	118
30.39161	51 20.13	2 29 7.0	+ .53	7.0	121
30.41103	16 51 23.19	+ 2 29 40.4	+0.99	— 6.0	121

June 7–9, 19, 23. No accurate places of the comparison-stars could be obtained.

Gohlis. Winkler. 6 in. R. *A.N.* 2797.

Gr. M.T.	α	δ	Δα	Δδ	*
June 13.46839	16 13 13.21	— 7 58 22.6	+1.25	+13.1	66
14.45962	15 26.40	7 14 39.1	1.11	—15.3	76
16.48353	19 58.73	5 46 51.4	0.25	(28.4)	86
17.46409	22 11.99	5 5 17.4	.81	21.1	84
18.47932	24 29.60	4 22 56.7	.86	1.2	88[1]
19.45156	26 40.91	3 43 45.8	.33	10.5	89
22.43750	33 26.52	1 48 51.6	.80	19.0	100
22.46461	33 30.19	1 47 51.4	.79	— 8.8	99
25.46974	40 17.40	0 1 46.9	.76	+ 5.3	109
25.49381	16 40 20.41	— 0 1 18.6	+0.51	—15.0	111

Göttingen. Clemens. 6 in. R? *A.N.* 2792.

Gr. M.T.	α	δ	Δα	Δδ	*
June. 15.46252	16 17 42.40	— 6 30 38.8	—0.13	—15.5	70
16.46674	19 57.02	5 47 27.4	+0.81	21.3	74
17.43164	22 6.96	5 6 33.3	0.17	—15.5	82
17.50755	22 18.74	5 2 55.2	(1.68	+12.0)	84
22.46764	16 33 31.08	— 1 47 43.6	+1.27	— 7.7	96

June 22. Condensation following the center.
Right-ascensions given half weight.

Greenwich. Turner. 6.7 in. *A.N.* 2797.

Gr. M.T.	α	δ	Δα	Δδ	*
June 12.50075	16 11 2.35	— 8 42 17.1	+0.29	+ 8.1	69
19.46981	26 44.16	3 43 10.4	1.10	—18.9	89
19.47455	16 26 43.84	— 3 42 50.3	+0.14	—10.1	90

June 12. Downing, observer.
June 18. Two observations by Hollis. No places for the comparison-stars.

Hamburg. Luther. 26 cm. *A.N.* 2792.

Gr. M.T.	α	δ	Δα	Δδ	*
June 16.48924	16 19 59.11	— 5 46 8.3	—0.14	+ 0.1	77
17.44567	22 8.33	5 5 43.0	—0.35	— 0.5	82
19.47826	16 26 44.26	— 3 42 31.1	+0.06	+ 0.2	90

Harrow. Tupman. 18 in. reflector R. *M.N.* 47.

Gr. M.T.	α	δ	Δα	Δδ	*
June 12.48266	16 11 0.03	— 8 43 17.9	+0.29	— 6.3	69
15.48574	17 44.21		.55		72
15.48574		6 29 35.5		12.8	75
17.49193	22 15.20	5 3 52.4	.25	6.0	82
19.47256	26 43.94	3 42 51.7	.51	— 6.7	89
22.45988	16 33 29.12	— 1 47 51.6	+0.33	+ 1.5	96

June 19. Time of observation changed 30m. Declinations given half weight.

Kiel. E. Lamp. 22 cm. *A.N.* 2786, 2787.

Gr. M.T.	α	δ	Δα	Δδ	*
	h m s	° ′ ″	s	″	
May 14.46069	15 13 37.04	—29 40 41.9	+0.98	— 2.2	1
16.46411	16 54.99	28 33 34.5	.52	+ 4.3	4
21.46071	15 25 37.84	—25 27 48.7	+0.90	— 3.9	18

Kremsmünster. Schwab. 15 cm? R. *A.N.* 2815.

Gr. M.T.	α	δ	Δα	Δδ	*
May 15.42241	15 15 11.70	—29 9 8.0	+1.21	— 5.0	8
26.42883	15 34 58.81	—21 58 58.7	(2.11)	— 0.6	36
June 13.45559	16 13 11.70	— 7 59 22.0	+1.36	— 9.8	68
15.40927	17 34.34	6 32 52.2	1.00	9.8	72
18.48806	24 30.65	4 22 35.2	0.73	1.3	87
19.44589	26 40.03	3 43 53.3	.22	4.4	89
19.46184	26 42.50	3 43 18.1	.52	7.5	88
23.45744	35 44.60	1 11 40.2	.54	1.9	107
24.40978	37 53.68	0 38 10.2	.55	7.2	102
25.45223	40 14.65	— 0 2 43.7	.38	16.2	108
27.46784	16 44 47.07	+ 1 2 41.4	+0.50	— 9.7	112
July 12.39980	17 17 33.27	+ 6 43 17.2	+0.76	— 3.3	138

Marseilles. Borrelly. 26 cm. *B.A.* Nov.

Gr. M.T.	α	δ	Δα	Δδ	*
May 14.37165	15 13 27.51	—29 43 34.6	+0.04	— 2.5	1
18.36692	20 9.30	27 25 58.9	.44	4.5	11
22.35549	27 15.29	24 51 44.8	.14	5.4	20
23.37532	29 8.86	24 9 52.6	.60	7.9	19
24.35691	30 59.12	23 28 40.5	.44	8.3	35
27.35843	15 36 45.99	—21 17 46.7	+0.35	— 1.7	37
June 8.38234	16 1 55.09	—11 53 57.6	+0.11	— 7.8	58
9.39752	4 9.09	11 6 6.8	.17	6.6	61
10.37724	6 19.02	10 20 28.1	.20	—17.1	63
11.37329	8 31.48	9 33 57.8	.04	+ 3.1	60
12.37022	10 44.83	8 48 24.8	.15	— 6.9	69
13.36755	12 58.91	8 3 19.0	.50	12.3	68
15.38741	17 30.73	6 33 53.2	.34	13.7	70
16.38071	19 44.93	5 51 0.0	.36	13.4	86
17.37259	21 58.82	5 9 1.2	.03	15.0	82
22.37443	33 16.98	1 51 8.0	.19	5.0	92
28.37096	16 46 48.66	— 1 30 30.6	—0.32	— 5.0	114

June 28. Comparison-star wrongly identified.

Nashville. Barnard. 6 in. R. *A.N* 2788, 2799, 2808.

Gr. M.T.	α	δ	Δα	Δδ	*
May 12.70370	15 10 48.93	—30 35 12.8	+1.72	+30.4	3
13.67494	12 21.19	30 5 46.9	1.25	—14.0	2
14.67514	13 57.95	29 33 39.8	1.11	+ 2.3	1
14.74035	14 3.79	29 31 46.9	0.61	—12.3	1
18.73726	20 48.02	27 12 21.2	+0.66	— 5.1	13
24.69693	31 35.87	23 15 0.7	(—1.41	+ 3.6)	25
25.66752	33 29.40	22 32 23.9	+0.94	— 6.8	31
25.68133	33 30.73	22 31 52.1	.68	12.0	34
26.72988	35 32.21	21 45 49.9	0.35	— 8.7	28
28.76663	15 39 34.26	—20 14 13.1	+1.16	+ 0.9	44
June 9.71467	16 4 52.29	—10 51 14.3	+1.38	— 6.5	61
9.72251	4 53.78	10 50 43.8	1.84	+ 2.0	59
10.69479	7 1.62	10 5 30.8	0.58	— 5.9	63
11.72622	9 19.05	9 17 39.5	.49	+ 6.8	65
16.71035	20 29.70	5 36 52.1	.44	— 8.7	79
17.66000	22 38.31	4 56 53.8	.60	8.4	82
17.66903	16 22 39.63	— 4 56 31.9	+ .69	— 9.0	83

Nashville. Barnard. 6 in R. *A.N.* 2788, 2799, 2808.

Gr. M.T.	α	δ	Δα	Δδ	*
	h m s	° ′ ″	s	″	
June 18.63047	16 24 49.44	— 4 16 57.8	+0.71	—12.9	88[1]
20.65218	29 24.81	2 56 25.1	1.34	7.4	94
23.65854	16 36 12.48	— 1 4 34.7	+1.16	— 7.3	96
July 9.62550	17 11 37.33	+ 5 58 12.5	1.04	— 6.1	128
9.65300	11 40.11	5 58 42.8	0.27	4.8	127
9.66477	11 42.15	5 58 54.4	0.79	5.7	132
9.66869	11 42.89	5 58 58.9	1.02	5.3	131
11.73836	16 8.96	6 33 12.2	0.95	5.9	134
13.66971	20 14.47	7 1 20.9	.41	5.1	147
14.67653	22 21.79	7 14 41.3	.34	0.4	133
15.65407	24 25.30	7 26 35.0	0.73	5.7	143
19.64170	32 42.44	8 6 52.2	1.22	5.1	149
20.65874	34 47.33	8 15 2.4	0.89	6.1	151
26.78141	17 47 10.98	+ 8 48 28.0	+1.37	—10.0	156
Aug. 10.67965	18 16 4.97	+ 8 44 15.3	(—2.18	—39.0)	165
11.68015	18 17 57.40	+ 8 41 52.1	(—3.22	+20.1)	165

June 18, July 8, 13, 16. No accurate places of the comparison-stars.

Nice. Charlois. 38 cm. *Bull. Astr.* June.

Gr. M.T.	α	δ	Δα	Δδ	*
June 14.46407	15 13 36.86	—29 40 36.5	+0.47	— 3.4	1
17.47329	18 37.30	27 58 18.2	.45	5.7	7
18.44711	20 17.53	27 23 2.9	.35	5.0	11
20.41350	23 44.67	26 8 47.8	.27	3.5	17
21.42043	25 33.56	25 29 18.5	.64	4.3	18
22.45050	27 26.10	24 47 52.8	.48	5.2	20
23.43402	29 15.21	24 7 21.9	.38	3.8	19
27.44854	36 56.49	21 13 55.2	.22	11.9	26
27.44854	15 36 56.48	—21 13 52.2	+0.21	— 8.9	45
July 7.36896	17 6 43.37	+ 5 15 45.3	+0.22	— 6.0	124
11.36625	15 20.57	6 27 23.1	.22	4.8	136
18.40294	30 7.95	7 55 53.5	.11	+ 1.2	149
23.40094	17 40 21.82	+ 8 33 22.2	+0.27	+ 1.7	154

Nicolajew. Kortazzi. 9 in. *A.N.* 2788.

Gr. M.T.	α	δ	Δα	Δδ	*
May 14.44389	15 13 34.57	—29 41 8.1	+0.13	+ 4.1	6
15.38764	15 8.47	24 9 58.2	(1.42	+14.5)	8
17.40076	18 29.16	18 0 49.1	—0.28	— 1.5	7
18.38868	20 11.75	27 25 7.5	+ .63	1.0	11
21.38625	15 25 29.46	—15 30 44.4	+0.26	— 8.8	18

Orwell Park. Plummer. 10 in. *M.N.* Nov.

Gr. M.T.	α	δ	Δα	Δδ	*
June 9.46403	16 4 17.91	—11 3 1.9	+0.19	— 9.0	59[2]
10.44986	6 29.00	10 16 46.3	.53	+ 1.8	64
12.48177	10 59.99	8 43 14.2	.37	— 1.2	69
13.45465	13 10.05	7 59 26.7	.84	—14.0	68
15.51720	17 48.69	6 28 0 0	.78	+ 0.7	72
17.45750	22 10.44	5 5 13.5	.15	— 0.7	83
18.45238	24 25.33	4 24 15.0	.24	13.5	88[1]
20.45384	28 56.86	3 3 52.2	.30	— 8.2	88[2]
22.51529	16 33 36.60	— 1 45 49.4	+0.32	+ 1.2	100
July 11.45022	16 15 31.48	+ 6 28 41.2	+0.37	— 6.4	134
12.47586	17 42.50	6 44 35.7	.27	+ 7.5	140
13.46525	19 48.36	6 58 49.1	.24	11.6	145
14.46847	21 55.57	7 12 10.6	.39	8.7	139
18.45757	30 14.65	7 56 33.9	.03	+10.7	149
19.48311	32 21.73	8 5 28.2	.15	— 8.1	148
20.46836	16 34 23.04	+ 8 13 46.9	+0.01	+ 6.7	153

ADDENDUM.

BY FRANK MULLER.

The following observations were omitted in preparing the copy for the printer, and the omission was not discovered until too late to insert them in their proper place on p. 49.

I take this opportunity of acknowledging the receipt, since the completion of my work, of observations of the comet made at Vienna, Nicolajew, and Cincinnati. I regret the omission of these observations, and had hoped that my request published in the *Astronomische Nachrichten* of June 8 would have insured their earlier publication.

1888 *July* 14.

Algiers. TRÉPIED. 50 cm. *A.N.* 2788; *B.A.*, Oct., Nov.

Gr. M.T.	α	δ	Δα	Δδ	*
June	h m s	° ′ ″	s	″	
9.37068	16 4 5.95	—11 7 24.4	+0.47	— 8.6	59
10.43735	6 27.64	10 17 34.7	+0.83	11.6	62
15.42039	17 35.50	6 32 19.0	+0.66	5.7	72
16.39474	19 47.13	5 50 22.5	+0.63	11.9	86
20.39425	28 48.44	3 6 41.0	—0.03	21.2	94
22.45514	33 27.28	1 48 16.9	+0.16	13.3	101
23.38888	16 35 34.74	— 1 16 37.4	(—0.02	—152.0)	107

Gr. M.T.	α	δ	Δα	Δδ	*
	h m s	° ′ ″	s	″	
Orwell Park. PLUMMER. 10 in. *M.N.* Nov.					
July 21.47249	16 36 26.53	+ 8 20 58.1	+0.25	— 9.1	154
24.46698	42 30.92	8 39 7.7	.10	+ 9.1	156
27.50462	48 36.83	8 51 12.9	.62	14.4	157
28.50153	17 50 35.48	+ 8 53 51.6	+0.28	+10.2	157
Padua. ABETTI. 7 in.? *A.N.* 2823.					
May 14.51634	15 13 42.21	—29 38 59.3	+0.76	— 7.7	1
18.47724	20 20.97	27 21 55.5	.66	4.0	11
20.49040	23 53.01	26 5 55.1	.38	8.7	16
20.49040	23 53.24	26 5 51.9	.61	5.5	17
21.45571	25 37.57	25 28 54.2	.83	5.2	18
24.46965	31 7.84	23 24 48.3	.39	3.2	32
24.46965	15 31 7.84	—23 24 49.9	+0.39	— 4.8	33
June 7.37704	15 39 43.45	—12 41 33.7	+0.39	— 4.9	51
8.37370	16 1 54.37	11 54 21.4	.53	7.1	58
8.37370	1 54.13	1 54 28.3	.29	14.0	58[1]
23.47867	16 35 47.63		+0.69		97
23.48737		— 1 10 44.8		—11.1	97
Palermo. AGNELLO. 25 cm. *A.N.* 2788, 2790.					
May 15.41719	15 15 10.75	—29 9 24.7	+0.77	—11.2	9
21.44685	23 34.27	25 29 19.7	(—1.51	68.6)	18
28.38754	38 48.50	20 31 33.0	+0.76	6.0	47
30.37860	42 49.57		1.33		50
31.35450	15 44 49.30	—18 15 0.6	+1.21	—18.0	49
May 15. ZONA, observer.					
Prague. WEINEK and GRUSS. 6 in. R. *A.N.* 2788.					
May 27.39249	15 36 50.42	—21 16 20.2	+0.76	— 6.5	37
27.41442	15 36 52.94	—21 15 16.5	+0.70	— 1.6	37

Gr. M.T.	α	δ	Δα	Δδ	*
	h m s	° ′ ″	s	″	
Rome. CERULLI. 9 in. R. *A.N.* 2787, 2801.					
May 14.43434	15 13 34.11	—29 41 38.7	+0.59	— 7.9	1
15.41784	15 15 9.90	—29 9 14.2	—0.14	— 2.0	9
July 8.36730	17 8 53.19	+ 5 35 11.1	—0.02	— 5.5	125
10.38359	13 14.42	6 11 16.2	+ .33	— 6.8	132
11.38434	15 22.55	6 27 46.7	— .12	+ 1.6	134
12.39276	17 31.91	6 43 11.3	+ .28	— 3.0	140
13.36287	19 35.56	6 57 10.5	+ .44	— 1.7	142
14.37836	21 43.64	7 10 52.4	— .16	+ 0.5	144
15.35634	23 47.53	7 23 11.7	+ .40	+ 4.5	144
16.42534	26 1.56	7 35 26.3	.24	— 5.5	146
17.38343	28 1.35	7 45 41.7	.32	(—78.1)	146
21.36128	36 12.84	8 20 23.0	.18	+ 3.0	151
22.36046	38 15.28	8 27 24.8	.44	20.0	154
24.41052	17 42 23.98	+ 8 38 57.4	+0.00	+15.6	155
Aug. 6.32891	18 7 49.20	+ 8 56 3.7	(—0.19	+22.5)	162
7.32986	18 9 44.21	+ 8 53 58.0	—0.35	+10.6	162
May 14, 15. MILLOSEVICH, observer.					
August 6. Observation doubtful.					
Scarborough. LOHSE. 15.5 in. *M.N.* 47.					
May 20.47065	15 23 50.73	—26 6 38.1	+0.21	— 5.7	17
21.51326	25 42.98	25 25 36.9	— .02	4.4	18
29.52798	15 41 5.08	—19 39 30.9	+0.29	— 6.4	49[1]
Washington. FRISBY. 9.6 in. *A.J.* 157.					
May 14.69101	15 13 59.30	—29 33 11.0	+0.93	+ 0.1	1
19.73697	22 32.08	26 34 49.6	— .22	— 3.1	15
21.61634	15 25 55.09	—25 21 34.8	+0.87	— 8.9	18

ADDITIONAL OBSERVATIONS.

After the solution of the normal equations there appeared, in *A.N.* 2835, observations made on ten nights by Herr KAMMERMANN at Geneva, and in *A.N.* 2837, observations on eight nights by M. STUYVAERT at Brussels.

These observations are referred chiefly to anonymous stars, and being distributed among six groups, the only effect, probably, would be slightly to increase the weights.

4. *Errors of Observation.*—In order to assign appropriate weights to a series of observations it is necessary to consider the mean, or probable, error of the series. This depends only upon the accidental errors; to determine which, however, the differences between the observed and computed places must first be freed from systematic errors.

Each difference consists of

I. Systematic errors;

ε_e, the error of the preliminary ephemeris

ε_p, the personal equation of the observer.

II. Accidental errors;

ε_o, the accidental error of observation.

ε_s, the error of the star-place.

I. Systematic errors.

a. Error of the preliminary ephemeris.

This error may be determined with sufficient accuracy for purposes of weighting by dividing the observations into groups, and taking the means of the differences with reference to the number of observations. The results are:

Mean Date	Δα	Δδ	No. Obs	Adopted Date.	Wt.
	s	″		1887	
May 22	+0.54	—5.2	92	142	6
June 12	.51	5.8	48	162	3
20	.42	9.3	66	172	4
July 11	.38	—1 2	31	192	2
21	+ .27	+3.9	27	202	2
Aug. 8	—0.13	+0.0	6	222	½

Solving by least squares the six equations of condition furnished, the errors of the ephemeris at any time t days from June 1 are, for right-ascension and declination respectively,

$$\left.\begin{aligned}\varepsilon_e &= 0^s.52 + 0^s.00112\,t + 0^s.0000631\,t^2 \\ \varepsilon_e &= -5''.5 \ -0''.0123\,t \ -0''.001373\,t^2\end{aligned}\right\} \qquad (1)$$

These errors added with changed signs to the differences will reduce them to the errors arising in observation.

b. Personal equation.

The method used to determine the personal equations was to compare the constant part of the error of the ephemeris as given by each observer with that given by the mean of all the observers, this mean being taken as the standard.

Having corrected each difference for the terms depending on t as given by equation (1) and taking the means for the different observers the results were those given in the columns headed $\Delta'\alpha$ and $\Delta'\delta$ in the following table; the next two columns contain the personal equations in right ascension and declination given with such signs that by their addition in the corresponding series the differences are freed from the personal errors of the observers. The last column contains the number of observations from which the mean $\Delta'\alpha$ and $\Delta'\delta$ were obtained.

	$\Delta'\alpha$	$\Delta'\delta$	ε_p α	ε_p δ	No. Obs.
	s	″			
Albany	+0.34	— 2.9	+0.17	—4.6	4
Algiers:					
Rambaud	.47	6.0	+0.04	—1.5	11 10
Trépied	.46	10.7	+0.05	+3.2	16 5
Berlin:					
Battermann	1.21	13.0	—0.70	+5.5	2
Knorre	0.41	6.9	+0.10	—0.6	2
Besançon:					
Gruey	0.41	9.2	+0.10	+1.7	11 5
Guillin	0.23	16.2	+0.28	+8.7	4
Herique	0.67	8.9	—0.16	+1.4	7
Bothkamp	0.53	6.6	—0.02	—0.9	6
Bordeaux:					
Courty	0.26	6.8	+0.25	—0.7	7
Flamme	0.45	5.4	+0.06	—2.1	11 3
Rayet	0.53	8.8	—0.02	+1.3	16 9
Cambridge, Mass.:					
Chandler	0.52	5.4	—0.01	—2.3	5
Wendell	0.10	4.1	+0.41	3.4	10
Cape of G. Hope	0.53	7.4	—0.02	0.1	6
Dresden	0.74	5.6	—0.23	1.9	4
Geneva	0.47	6.5	+0.04	—1.0	15
Gohlis	.79	8.7—	—0.28	(+1.2)	10 9
Göttingen	0.56	15.5	—0.05	(+8.0)	4
Greenwich:					
Downing	0.31	7.8	+0.20	(+0.3)	1
Turner	+0.66	15.2	—0.15	(+7.7)	1
Hamburg	—0.11	0.6	+0.62	—6.9	2
Kiel	+0.80	11.7	—0.29	+4.2	3
Marseilles	0.26	8.3	+0.25	+0.8	17
Nashville	0.91	6.2	—0.40	(—1.3)	28 18
Nice	0.39	4.6	+0.12	—2.9	13 9
Nicolajew	0.17	2.0	0.34	5.5	4
Orwell Park	0.45	5.2	+0.06	2.3	20 9
Padua	0.55	7.0	—0.4	—0.5	11
Palermo:					
Agnello	+1.10	—12.0	—0.59	+4.5	3 2
Zona	+0.77	—11.4	—0.26	+3.9	1
Prague:					
Gruss	0.70	1.6	0.19	—5.9	1
Weinek	0.76	6.5	—0.25	1.0	1
Rome:					
Cerulli	0.30		+0.21		13
Millosevich	0.22	5.2	+0.29	2.3	2
Washington	+0.53	—4.1	—0.02	—3.4	3
Mean	+0.51	—7.5			

In taking the above means, each independent observer was given equal weight; when only a few observations are made the personal error may, of course, be masked by the accidental errors, but in the mean these errors are nearly eliminated by a number of such short series. In fact, taking the means somewhat with regard to the number of observations, the results were $+0^s.51$ and $-7''.4$.

In July the comet became elongated north and south, and difficult to observe in declination. By this change of form the accidental errors become larger, and there is reason to suppose that the personal error of observing in declination may have changed. Hence the observations made in July and August were not used in determining the personal equations; and since not enough observations were made for a separate determination, no personal equations were applied to the observations made during these months.

In observations made with a ring-micrometer the personal equation in declination has opposite effects, according as the comet is north or south of the star, and is nearly eliminated in a number of observations. The personal equations cannot therefore be obtained without a consideration of the relative positions of the star and the comet. The quantities corresponding to them are inclosed in brackets, and they should be, when depending upon a number of observations, small.

The Harrow, Kremsmünster, and Scarborough observations were received too late to be used in determining the personal equations.

Since the observations have been used once with equal weights for all the observations by an independent observer, their weights in the formation of the normal places must be reduced in consequence. When only one observation was made, it was used only in the determination of personal equation; when two were made, each was given only half weight in the formation of the normal places; when three were made the weight of each was reduced one-third, and so on until the reduction became insignificant.

II. Accidental Errors.

Errors of observation and star-places. Determination of probable error.

Each difference between the observed and computed positions may be reduced so as to contain only these errors and the personal error, by correcting for the terms involving t, as given by equation (1), and for the constant terms,

$0^s.51$ and $7''.5$, given by the mean of all the observations. These corrections are given for every tenth day, in the following table:

	$\Delta(\Delta\alpha)$	$\Delta(\Delta\delta)$
	s	″
May 12	—0.51	+7.20
22	0.51	7.48
June 1	0.51	7.50
11	0.493	7.24
21	0.463	6.70
July 1	0.419	5.90
11	0.364	4.82
21	0.296	3.46
31	0.215	+1.83
Aug. 10	—0.123	—0.07

The corrections from this table being added to the differences of a given observer, the mean of the resulting differences will with changed sign, be the personal error of that observer.

Let $v_1, v_2, \ldots v_i$ be the residuals of the individual differences from this mean, then

$$v^2 = \varepsilon_0^2 + \varepsilon_s^2$$

If ε_1 be the mean error of observation in an observation depending upon a single comparison,

$$\varepsilon_1^2 = \frac{[n\varepsilon_0\varepsilon_0]}{i-1}$$

where $[n\varepsilon_0\varepsilon_0] = n_1\,\varepsilon_{0\,1}^2 + n_2\,\varepsilon_{0\,2}^2 + \ldots + n_i\,\varepsilon_{0\,i}^2$

Substitution gives

$$(2) \qquad \varepsilon_1^2 = \frac{[nvv] - [n\varepsilon_s\,\varepsilon_s]}{i-1} \,;$$

and the mean error of an observation depending upon a number of comparisons n is

$$(3) \qquad \varepsilon = \sqrt{\left(\frac{\varepsilon_1^2}{n} + \varepsilon_s^2\right)}$$

When the star-places are carefully determined, ε_s will usually be small in comparison with ε_0 and the probable error will then be approximately given by

$$(4) \qquad r = 0.6745\sqrt{\frac{[nvv]}{n(i-1)}} \,,$$

which is the formula commonly used.*

There is however an objection to weighting strictly in accordance with this, or any other similar formula. On each night there are undetermined instrumental and personal errors peculiar to that night; such errors are not diminished by an increased number of comparisons, hence the insufficiency of a formula in which the probable error depends solely upon the number of comparisons. I have used (4) when the number of comparisons did not exceed sixteen, but I have assumed that the probable error was not diminished by a number of comparison greater than this. This limit is probably too great, while the comet was strongly condensed.

The calculated probable errors of a single comparison, arranged in order of the size of the instrument, are:

Place and Observer	Probable Error		Aperture
	s	″	cm
Algiers, Rambaud	1.02	6.6	50
" Trépied	0.92	10.8	50
Cambridge, Wendell	0.50	6.3	38
Nice, Charlois	0.18	{ 1.4, 5.5	38
Bordeaux, Courty	1.03	10.8	36
" Flamme	0.45	9.9	36
" Rayet	0.79	{ 7.6, 12.3	36
Marseilles, Borrelly	0.31	6.7	26
Orwell Park, Plummer	0.39	{ 15.0, 17.3	25
Geneva, Kammermann	0.82	8.7	25
Rome, Cerulli	0.47	6.8	23 R
Besançon, Gruey	0.94	(*28.0)	20
" Herique	0.67	11.9	20
Padua, Abetti	0.44	5.5	18?
Gohlis, Winkler	0.65	26.0	15 R
Kremsmünster, Schwab	0.61	9.3	15 R
Nashville, Barnard	0.61	8.4	15 R

* Adopted probable error, 20″.

When two errors are given, the latter refers to the observations made in July and August when the comet was more difficult to observe in declination; in most cases there was no difference. All the Rome observations were made during these months. As a guide to assigning probable errors in accordance with the size of the instrument used, I have grouped these results.

Aperture	Mean Aper.	Prob. Error		No. of Obs.
cm cm	cm	s	″	
15 — 18	16	0.58	12.3	4
20 — 26	24	0.60	10.1	5 , 4
36 — 38	37	0.59	8.1	5

The solution of the equations of condition, taken with equal weights, shows that the probable error in declination may be nearly represented by the equation

$$r = 10''.3 + (25-a)\;0''.20 \,, \qquad (5)$$

for apertures between 15^{cm} and 40^{cm}, a being the aperture in centimeters. The probable error in right-ascension appears to be independent of the aperture.

The probable error of each observer was calculated by (4) when the number of observations was seven or more. In other cases it was, the aperture of instrument being the only available guide, assigned by (5) and taken as $0^s.60$ in right-ascension. The weight was then calculated by

$$p = \frac{r_0^2}{r^2} = \frac{(5''.5)^2}{r^2}$$

* The accurate formula is, however, not much more difficult in application, and when the error of observation is small, the discrepancies arising from the use of the approximate formula may become appreciable. The mean error would be determined from (2) by assigning to each observation a value of ε_s in accordance with the mean error of the catalogue on the authority of which the place of the comparison-star rested; then, for each observation,

$$r = 0.6745\sqrt{\frac{\varepsilon_1^2}{n} + \varepsilon_s^2} \,,$$

ε_s being assigned as before.

5″.5 being assumed as the probable error of a single comparison in a standard observation.

5. *Formation of Normal Places.* — Weights being given to each observation, and personal equation applied, in accordance with the preceding results, the residuals were divided into groups, and their weighted means taken.

Group	Mean Date	(O—C) $\Delta\alpha$	(O—C) $\Delta\delta$	No. of Obs.		Weight	
		s	″				
May 12–21	17.8	+0.620	— 6.65	48		152	180
May 22–31	26.0	.503	6.80	42		146	168
June 1–16	12.9	.502	7.70	63	62	214	136
June 17–30	21.8	.385	8.57	68		206	135
July 1–14	10.5	.377	— 1.32	34	33	104	75
July 15–31	22.2	.303	+ 2.04	27	26	115	43
Aug. 1–10	8.4	+0.141	+ 4.20	6		25	14

The corresponding normal places are:—

Date		α	δ
		° ′ ″	° ′ ″
1887 May	18.0	229 52 47.92	—27 39 28.87
	26.0	233 31 43.66	22 17 58.58
June	13.0	243 2 12.91	8 19 54.68
	22.0	248 6 29.18	— 2 5 11.54
July	10.0	258 5 2.11	+ 6 4 43.29
	22.0	264 22 33.85	8 24 39.87
Aug.	8.0	272 45 11.59	+ 8 52 17.07

6. *Formation of Normal Equations and Determination of Definitive Elements.* — The coefficients of the variations of the elements were computed by the formulas given by OPPOLZER.* Whence were formed the following

* Lehrbuch zur Bahnbestimmung. Zweiter Band, pp. 405–406.

EQUATIONS OF CONDITION (coefficients logarithmic).

Right-Ascension.

$$0.9158\ \Delta\alpha\cos\delta = 9.1014\ \delta i' + n9.7910 \sin i'\ \delta\Omega' + 0.5091\ \delta\pi' + 0.6943\ \delta\log q + n8.6336\ \delta T + n9.4702\ \delta e$$

$\Delta\alpha\cos\delta$	$\delta i'$	$\sin i'\ \delta\Omega'$	$\delta\pi'$	$\delta\log q$	δT	δe
0.9158	9.1014	n9.7910	0.5091	0.6943	n8.6336	n9.4702
0.8439	9.3201	n9.7866	0.5296	0.6382	n8.6698	n9.3811
0.8722	9.5725	n9.6509	0.5267	0.3633	n8.6929	n8.6523
0.7601	9.6108	n9.4889	0.4993	0.0396	n8.6719	8.8019
0.7465	9.5663	n8.5065	0.4145	n9.9454	n8.5856	9.3627
0.6557	9.4678	9.0244	0.3502	n0.2324	n8.5105	9.4675
0.3323	9.2351	+ 9.3578	+ 0.2622	+ n0.3689	+ n8.3957	+ 9.5169

Declination.

$\Delta\delta$	$\delta i'$	$\sin i'\ \delta\Omega'$	$\delta\pi'$	$\delta\log q$	δT	δe
n0.8228	= n0.5027	+ n9.7115	+ 9.0392	+ 9.9016	+ n6.7537	+ 7.5274
n0.8325	n0.5168	n9.9688	9.3296	9.4857	n7.4650	n8.1708
n0.8865	n0.4630	n0.2538	9.7602	n0.1533	n7.9423	n7.9174
n0.9330	n0.3902	n0.3102	9.8723	n0.3483	n8.0196	8.1229
n0.1399	n0.1846	n0.3282	9.9686	n0.4771	n8.0424	8.6720
0.3032	n0.0168	n0.3278	9.9782	n0.4762	n7.9908	8.7276
0.6149	n9.7208	+ n0.2965	+ 9.9526	+ n0.4242	+ n7.9062	+ 8.6984

After multiplying each equation by the square root of its weight, and rendering all the equations homogeneous by the introduction of the factors

$$x = 1.6303\ \delta i' \qquad t = 1.7852\ \delta\log q$$
$$y = 1.3754\ \delta\Omega' \sin i \qquad u = 9.8581\ \delta T$$
$$z = 1.6919\ \delta\pi' \qquad w = 0.7159\ \delta e$$
$$\text{residual unit} = 2.0374$$

the normal and elimination equations were obtained and checked in the usual way.

NORMAL EQUATIONS (natural numbers).

x	y	z	t	u	w		
+3.2495 x	+2.4326 y	+0.0344 z	+0.6054 t	—0.0712 u	+0.0262 w	=	+3.2908
+2.4326	+3.5101	—1.5012	+0.3476	+1.3998	+0.3285	=	+1.3221
+0.0344	—1.5012	+3.8590	+1.8300	—3.7560	—0.3742	=	+3.2762
+0.6054	+0.3476	+1.8300	+2.8651	—1.7499	+1.5851	=	+2.5187
—0.0712	+1.3998	—3.7560	—1.7499	+3.6648	+0.3049	=	—3.1962
+0.0262	+0.3285	—0.3742	—1.5851	+0.3049	+1.5346	=	—0.5268

ELIMINATION EQUATIONS (coefficients logarithmic).

x	y	z	t	u	w		
+0.51181 x	+0.38607 y	+8.53656 z	+9.78204 t	+n8.85248 u	+8.41830 w	=	0.51730
	0.22763	n0.18384	n9.02366	0.16230	9.48982	=	n0.05748
		0.39412	0.23756	n0.38766	n8.97864	=	0.34428
			0.18772	8.75435	n0.17734	=	9.46761
				7.74036	7.14613	=	8.38021
					7.69897	=	8.32015

Direct solution of these equations gave

$$\log x = 0.3653 \qquad \delta i' = +\ 5.92$$
$$\log y = 0.4387 \qquad \delta\Omega' = -33.13$$
$$\log z = 0.1488 \qquad \delta\pi' = +\ 3.12$$

$$\log t = 0.6181 \qquad \delta\log q = +0.0000360$$
$$\log u = 0.5185 \qquad \delta T = +0.002418$$
$$\log w = 0.6212 \qquad \delta e = +0.0004249$$

The small coefficients in the equations involving u and w alone, show that the values obtained by direct solution are highly uncertain. An attempt was made to diminish this uncertainty by expressing the other unknown quantities in terms of w and an absolute term. Accordingly,

$$\begin{aligned} x &= 9.93648 + 0.16283\, w \\ y &= 9.39094 + n0.47594\, w \\ z &= 0.71350 + n0.57532\, w \\ t &= 8.47124 + 0.61496\, w \\ u &= 0.63985 + n0.02695\, w \end{aligned}$$

the coefficients being logarithmic.

Substitution in the equations of condition and solution of the fourteen resulting equations for w gave

(1) $\log w = 0.6604$;

the corresponding changes of the elements are given in the column numbered I in the table below. Comparison with the normal places gave — 9″.86 as the sum of the weighted residuals, showing that the uncertainty of solution had not been wholly eliminated. To determine by trial what variation of the eccentricity would best distribute the residuals, an assumption was made, —

(2) $\log w = 0.6814$,

which gave the changes of the elements numbered II. Comparison with the normal places gave the residuals numbered II. Interpolation between the values (1) and (2) gave

(3) $\log w = 0.6788$

The results of this assumption are given in the columns numbered III. They show no improvement on the results of the second hypothesis. The residuals given by direct comparison being so nearly equal, it was considered safe to interpolate between them, on the assumption that the sum of the weighted residuals should be zero. The weighted values are numbered (IV) and the sum of their squares being slightly smaller than for the other assumed variations of the eccentricity, the value

(4) $\log w = 0.6801$

was taken as the definitive value.

Changes of Elements.

	I	II	III
δT	+ 0.002344	+ 0.002301	+ 0.002307
$\delta \pi'$	+ 2″.33	+ 1″.88	+ 1″.94
$\delta i'$	+ 6.27	+ 6.47	+ 6.45
$\delta ☊'$	—36″.59	—38″.55	—38″.33
$\delta \log q$	+ 0.0000393	+ 0.0000413	+ 0.0000411
δe	+ 0.0004650	+ 0.0004880	+ 0.0004852

Residuals (Normal—Computed).

Unweighted.		Weighted		
II	III	II	(IV)	III
Right-Ascension.				
+1″.08	+0″.91	+1″.33	+1″.23	+1″.12
—0.59	—0.57	—0.72	—0.71	—0.70
+0.21	+0.17	+0.31	+0.28	+0.25
—0.89	—0.94	—1.28	—1.31	—1.35
+0.61	+0.53	+0.62	+0.58	+0.54
0.72	0.64	0.77	0.73	0.68
+0.80	+0.76	+0.40	+0.39	+0.38
Declination.				
—0.60	—0.84	—0.80	—0.96	—1.13
+0.59	+0.25	+0.76	+0.54	+0.32
+0.75	+0.41	+0.88	+0.68	+0.48
—1.43	—1.77	—1.66	—1.86	—2.05
+0.81	+0.53	+0.70	+0.58	+0.46
+0.75	+0.34	+0.50	+0.36	+0.22
—1-27	—1.67	—0.47	—0.54	—0.62
Sum +1.54	—1.25	+1.36	—0.01	—1.40

All the weights have been divided by 100 for convenience. The sums of the squares of the residuals are:

	II	(IV)	III
Unweighted	10″.02	10″.11	10″.59
Weighted	10.87	10.72	10.96

Transforming the preliminary elements from the ecliptic to the equator, and adding the changes interpolated between II and III, the resulting definitive elements of Comet 1887 IV are:

$$\begin{aligned} T &= \text{June } 16.663384 \text{ Gr. M.T.} \\ \pi' &= 257^\circ\ 4'\ 4''.38 \\ ☊' &= 313\ \ 54\ \ 12\ .14 \\ i' &= 22\ \ 20\ \ \ 9\ .02 \end{aligned} \Bigg\}\ \text{Mean Equator 1887.0}$$

$$\begin{aligned} \log q &= 0.1442046 \\ e &= 0.9960879 \end{aligned}$$

Constants for the Equator.

$$\begin{aligned} x &= r\,[9.9830763]\sin(349^\circ\ 18'\ 5''.82+v) \\ y &= r\,[9.9843699]\sin(254\ \ 50\ \ 26\ .90+v) \\ z &= r\,[9.5798234]\sin(303\ \ \ 9\ \ 52\ .24+v) \end{aligned}$$

Leander McCormick Observatory, Univ. Virginia, 1888 *May* 26.