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DEFINITIVE ORBIT OF COMET
1827 II (PONS)

AND

ON THE ORBITS OF TWO COMETS
OBSERVED IN JAPAN

BY

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Tokyo,—1917.

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ON THE ORBITS OF TWO COMETS OBSERVED IN JAPAN.

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DEFINITIVE ORBIT OF COMET 1827 II (PONS).

By

S. Ogura.

(1) Introduction.

The second comet of 1827 was discovered by Pons in Florence on the night of June 20, 1827. It was also independently discovered by Gambart in Marseilles. From the constellation of Cassiopeia, it moved rapidly towards the north, the nearest approach to the north pole being attained on the morning of June 26 ($\delta=+82^{\circ} 50'$, $\alpha=6^h 56^m$). Thence it moved southwards, passing through the Dipper in Ursa Major, and was last observed on July 21 in the constellation of Canes Venatici. Besides these observations made by Pons, it was also observed in Nimes on July 5. The heliocentric arc described was 41° . The minimum distance from the earth was 0.530 on June 21.

(2) Sun's Coordinates and Star Constants.

The places of the Sun have been computed from Newcomb's table of the Sun. They are referred to the mean equinox for the beginning of the year. The mean obliquity of the ecliptic for 1827.0 was found to be $23^{\circ} 27' 42''.45$.

Sun's Places for Greenwich Mean Noon.

Date	Longitude			Latitude	log <i>R</i>	Sidereal Time at Mean Noon		
1827	°	'	"	"		<i>h</i>	<i>m</i>	<i>s</i>
June 19	87	21	30.01	+ 0.10	0.0070592	5	47	45.43
20	88	18	44.98	— 0.02	0.0070873	5	51	41.98
21	89	15	59.67	— 0.15	0.0071130	5	55	38.54
22	90	13	14.14	— 0.27	0.0071362	5	59	35.09
23	91	10	28.39	— 0.38	0.0071568	6	3	31.65
24	92	7	42.36	— 0.46	0.0071749	6	7	28.20
25	93	4	56.06	— 0.54	0.0071905	6	11	24.76
26	94	2	9.52	— 0.58	0.0072035	6	15	21.31
27	94	59	22.64	— 0.59	0.0072139	6	19	17.87

Date	Longitude			Latitude	log <i>R</i>	Sidereal Time at Mean Noon		
1827	°	'	"	"		<i>h</i>	<i>m</i>	<i>s</i>
June 28	95	56	35.46	− 0.55	0.0072219	6	23	14.42
29	96	53	47.96	− 0.55	0.0072274	6	27	10.93
30	97	51	0.12	− 0.50	0.0072305	6	31	7.54
July 1	98	48	11.94	− 0.40	0.0072313	6	35	4.09
2	99	45	23.45	− 0.29	0.0072300	6	39	0.65
3	100	42	34.64	− 0.16	0.0072267	6	42	57.20
4	101	39	45.55	− 0.03	0.0072215	6	46	53.76
5	102	36	56.25	+ 0.11	0.0072145	6	50	50.31
6	103	34	6.79	+ 0.24	0.0072059	6	54	46.87
7	104	31	17.25	+ 0.36	0.0071958	6	58	43.42
8	105	28	27.78	+ 0.45	0.0071844	7	2	39.98
9	106	25	38.45	+ 0.51	0.0071715	7	6	36.53
10	107	22	49.38	+ 0.53	0.0071573	7	10	33.09
11	108	20	0.68	+ 0.54	0.0071417	7	14	29.64
12	109	17	12.45	+ 0.50	0.0071246	7	18	26.20
13	110	14	24.76	+ 0.43	0.0071059	7	22	22.76
14	111	11	37.71	+ 0.35	0.0070854	7	26	19.31
15	112	8	51.30	+ 0.25	0.0070631	7	30	15.87
16	113	6	5.55	+ 0.14	0.0070388	7	34	12.42
17	114	3	20.56	0.00	0.0070124	7	38	8.98
18	115	0	36.27	− 0.11	0.0069839	7	42	5.53
19	115	57	52.74	− 0.22	0.0069530	7	46	2.09
20	116	55	9.91	− 0.33	0.0069199	7	49	58.64
21	117	52	27.82	− 0.43	0.0068844	7	53	55.20
22	118	49	46.48	− 0.50	0.0068464	7	57	51.75

From these values, the following rectangular coordinates were obtained.

Rectangular Coordinates of the Sun for Greenwich Mean Noon.

Date	<i>X</i>	<i>Y</i>	<i>Z</i>
1827			
June 19	+ 0.0468447	+ 0.9313672	+ 0.4042323
20	+ 0.0299328	+ 0.9320141	+ 0.4045123
21	+ 0.0130117	+ 0.9323975	+ 0.4046781
22	− 0.0039139	+ 0.9325171	+ 0.4047294
23	− 0.0208390	+ 0.9323727	+ 0.4046661
24	− 0.0377583	+ 0.9319642	+ 0.4044883
25	− 0.0546669	+ 0.9312922	+ 0.4041962
26	− 0.0715600	+ 0.9303563	+ 0.4037897
27	− 0.0884321	+ 0.9291572	+ 0.4032693
28	− 0.1052784	+ 0.9276954	+ 0.4026351
29	− 0.1220939	+ 0.9259717	+ 0.4018869
30	− 0.1388736	+ 0.9239865	+ 0.4010256

DEFINITIVE ORBIT OF COMET 1827 II (PONS).

Date	<i>X</i>	<i>Y</i>	<i>Z</i>
1827			
July 1	— 0.1556127	+ 0.9217408	+ 0.4000514
2	— 0.1723063	+ 0.9192355	+ 0.3989647
3	— 0.1889497	+ 0.9164716	+ 0.3977659
4	— 0.2055384	+ 0.9134509	+ 0.3964555
5	— 0.2220679	+ 0.9101738	+ 0.3950339
6	— 0.2385337	+ 0.9066416	+ 0.3935016
7	— 0.2549317	+ 0.9028562	+ 0.3918592
8	— 0.2712579	+ 0.8988183	+ 0.3901071
9	— 0.2875079	+ 0.8945288	+ 0.3882458
10	— 0.3036777	+ 0.8899892	+ 0.3862756
11	— 0.3197632	+ 0.8852001	+ 0.3841971
12	— 0.3357599	+ 0.8801632	+ 0.3820109
13	— 0.3516638	+ 0.8748788	+ 0.3797169
14	— 0.3674703	+ 0.8693479	+ 0.3773160
15	— 0.3831750	+ 0.8635722	+ 0.3748086
16	— 0.3987729	+ 0.8575527	+ 0.3721955
17	— 0.4142599	+ 0.8512908	+ 0.3694769
18	— 0.4296313	+ 0.8447879	+ 0.3666540
19	— 0.4448823	+ 0.8380456	+ 0.3637271
20	— 0.4600084	+ 0.8310658	+ 0.3606972
21	— 0.4750051	+ 0.8238502	+ 0.3575649
22	— 0.4898680	+ 0.8164006	+ 0.3543312

The independent star constants have been computed for Greenwich mean noon of every second day with the help of Bausinger's "Tafeln zur Theoretischen Astronomie."

Star Constants for Greenwich Mean Noon.

Date	<i>f</i>	log <i>g</i>	<i>G</i>	log <i>h</i>	<i>H</i>	log <i>i</i>
1827						
June 18	+ 31.90	1.1963	28 0	1.3110	183 18	9.7076 _n
20	+ 32.20	1.1996	27 49	1.3111	181 32	9.3802 _n
22	+ 32.51	1.2030	27 38	1.3111	179 47	8.4771
24	+ 32.81	1.2063	27 27	1.3111	178 2	9.4771
26	+ 33.12	1.2095	27 16	1.3110	176 17	9.7559
28	+ 33.42	1.2127	27 4	1.3108	174 32	9.9243
30	+ 33.72	1.2159	26 52	1.3105	172 47	0.0453
July 2	+ 34.02	1.2190	26 40	1.3101	171 2	0.1399
4	+ 34.32	1.2220	26 28	1.3097	169 16	0.2175
6	+ 34.61	1.2249	26 15	1.3092	167 31	0.2810
8	+ 34.91	1.2278	26 3	1.3086	165 45	0.3385
10	+ 35.20	1.2306	25 50	1.3080	163 58	0.3874
12	+ 35.48	1.2334	25 37	1.3073	162 12	0.4298
14	+ 35.77	1.2361	25 24	1.3066	160 25	0.4698
16	+ 36.05	1.2387	25 11	1.3058	158 37	0.5051
18	+ 36.33	1.2413	24 58	1.3049	156 49	0.5378
20	+ 36.60	1.2438	24 45	1.3039	155 1	0.5670
22	+ 36.87	1.2462	24 32	1.3029	153 12	0.5944
24	+ 37.14	1.2486	24 20	1.3019	151 23	0.6201

(3) Elements and Ephemeris.

Heiligenstein obtained the following elements from the observations in Florence made on June 20, July 6 and 21 (*Ast. Nach.* 134).

$$\begin{aligned}
 T &= 1827 \text{ June } 7.84115 \text{ Greenwich Mean Time.} \\
 \omega &= 20^\circ 38' 46'' \\
 \Omega &= 318 \quad 10 \quad 28 \\
 i &= 136 \quad 21 \quad 15 \quad \left. \vphantom{\begin{matrix} \omega \\ \Omega \\ i \end{matrix}} \right\} 1827.0 \\
 \log q &= 9.907494
 \end{aligned}$$

The constants for the equator are:

$$\begin{aligned}
 x &= [9.948305] r. \sin (v + 143^\circ 34' 19''.5) \\
 y &= [9.992546] r. \sin (v + 239 \quad 7 \quad 55.5) \\
 z &= [9.695108] r. \sin (v + 348 \quad 15 \quad 4.6)
 \end{aligned}$$

The calculated position for the middle observation with these elements fairly well represents the declination, but there is a deviation of more than 1' in right ascension. The ephemeris was computed from the above elements, and comparing it with the observations, the following approximate normal places, each of them built from the observations during 3 or 4 days, were obtained. They are referred to the equator and the mean equinox of 1827.0, and are corrected for parallax and aberration.

	June 21.5	July 5.5	July 20.5
α	$34^\circ 13' 48''.3$	$179^\circ 54' 53''.3$	$185^\circ 54' 41''.9$
δ	$+70 \quad 15 \quad 56.6$	$+59 \quad 55 \quad 39.5$	$+40 \quad 26 \quad 24.1$

From these the following elliptic elements were obtained.

$$\begin{aligned}
 T &= 1827 \text{ June } 7.10260 \text{ Greenwich Mean Time.} \\
 \omega &= 19^\circ 8' 16''.8 \\
 \Omega &= 317 \quad 36 \quad 20.5 \\
 \pi &= 336 \quad 44 \quad 37.3 \\
 i &= 136 \quad 26 \quad 46.2 \quad \left. \vphantom{\begin{matrix} \omega \\ \Omega \\ \pi \\ i \end{matrix}} \right\} 1827.0 \\
 \log q &= 9.906549 \\
 \log e &= 9.974730
 \end{aligned}$$

The equatorial constants are as follows:

$$\begin{aligned}
 x &= [9.9472070] r. \sin (v + 142^\circ 37' 40''.82) \\
 y &= [9.9929880] r. \sin (v + 238 \quad 4 \quad 53.62) \\
 z &= [9.6968744] r. \sin (v + 346 \quad 29 \quad 25.94)
 \end{aligned}$$

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The substitution for the middle observation is $d\lambda \cos \beta = +0.''5$ and $d\beta = -0.''5$. These elements were taken as the basis of further investigation, and with these the following ephemeris was computed.

Ephemeris for Greenwich Mean Noon.

Date		α (true)			δ (true)			Aberr. Time
1827		<i>h</i>	<i>m</i>	<i>s</i>	<i>°</i>	<i>'</i>	<i>"</i>	<i>m</i> <i>s</i>
June	19	1	46	0.71	+59	48	16.7	4 28.8
	20	1	55	20.58	+63	59	34.2	4 25.9
	21	2	8	23.71	+68	11	29.7	4 24.4
	22	2	27	33.89	+72	18	37.9	4 24.5
	23	2	57	35.17	+76	12	48.5	4 26.0
	24	3	48	5.10	+79	39	19.0	4 29.1
	25	5	15	11.10	+82	7	20.0	4 33.5
	26	7	18	10.65	+82	46	54.6	4 39.3
	27	9	5	5.83	+81	26	56.1	4 46.3
	28	10	10	17.78	+79	1	12.8	4 54.4
July	29	10	48	10.87	+76	13	31.3	5 3.7
	30	11	11	39.08	+73	22	49.6	5 13.8
	1	11	27	16.39	+70	36	44.9	5 24.8
	2	11	38	17.81	+67	58	23.9	5 36.5
	3	11	46	26.73	+65	28	48.3	5 48.9
	4	11	52	40.74	+63	8	47.6	6 1.8
	5	11	57	35.80	+60	57	40.6	6 15.2
	6	12	1	34.08	+58	55	14.8	6 29.1
	7	12	4	50.24	+57	0	59.6	6 43.3
	8	12	7	34.62	+55	14	20.9	6 57.9
	9	12	9	54.16	+53	34	46.0	7 12.7
	10	12	11	54.51	+52	1	40.9	7 27.7
	11	12	13	39.38	+50	34	34.6	7 43.0
	12	12	15	11.83	+49	12	58.1	7 58.4
	13	12	16	34.08	+47	56	23.5	8 13.9
	14	12	17	47.94	+46	44	26.5	8 29.5
	15	12	18	54.88	+45	36	44.0	8 45.2
	16	12	19	56.01	+44	32	55.0	9 1.0
	17	12	20	52.25	+43	32	40.7	9 16.8
	18	12	21	44.43	+42	35	44.2	9 32.6
	19	12	22	33.12	+41	41	49.7	9 48.5
	20	12	23	18.87	+40	50	42.8	10 4.3
	21	12	24	2.07	+40	2	11.3	10 20.1
	22	12	24	43.18	+39	16	2.9	10 35.9

(4) Mean Places of the Comparison Stars.

The mean places of the comparison stars were found in the usual way. The places of the stars which are found in Boss's "Preliminary General Catalogue" were taken without any correction, and the others were all reduced to the system

of Boss, applying the systematic corrections and weights as given in his catalogue. Newcomb's constant of precession was used to reduce the mean places of the comparison stars to those for 1827.0.

Mean Places of the Comparison Stars for 1827.0.

*	α			δ			Authority
	<i>h</i>	<i>m</i>	<i>s</i>	<i>°</i>	<i>'</i>	<i>"</i>	
1	2	14	56.32	+ 66	37	2.9	Boss 550
2	2	53	24.83	+ 73	43	28.1	Boss 705
3	3	57	24.39	+ 80	23	17.4	Boss 977
4	4	28	21.97	+ 80	52	48.3	Boss 1124
5	11	4	14.90	+ 74	57	52.8	AG Berl C 1542, AG Kas 2112
6	11	5	29.16	+ 75	16	48.4	AG Berl C 1545, AG Kas 2116
7	11	8	48.74	+ 75	21	59.3	AG Berl C 1551, AG Kas 2123
8	11	21	1.66	+ 70	17	5.5	Boss 3031
9	11	24	45.94	+ 75	11	48.4	AG Berl C 1575, AG Kas 2152
10	11	25	48.00	+ 70	17	4.5	Boss 3050
11	11	31	26.97	+ 69	54	36.6	AG Berl C 1593
12	11	32	44.40	+ 67	42	6.4	Boss 3081
13	11	41	53.77	+ 69	47	49.2	AG Chri 1827
14	11	47	47.60	+ 62	30	48.5	AG Hels 6962
15	11	49	16.81	+ 62	25	40.6	AG Hels 6972
16	11	50	14.76	+ 62	17	52.7	AG Hels 6975
17	11	52	6.64	+ 63	57	35.2	AG Hels 6987
18	11	52	25.21	+ 67	5	11.3	AG Chri 1845
19	11	56	51.92	+ 63	53	59.5	Boss 3157
20	11	59	33.79	+ 59	31	9.0	AG Hels 7032
21	12	3	4.89	+ 58	1	4.6	Boss 3179
22	12	6	49.35	+ 57	59	40.0	Boss 3190
23	12	8	18.02	+ 64	35	21.8	AG Hels 7092
24	12	12	18.64	+ 64	37	52.5	AG Hels 7117
25	12	12	25.52	+ 58	49	41.8	Boss 3219
26	12	12	29.29	+ 46	28	33.6	AG Bo 8460
27	12	13	25.04	+ 48	8	36.2	AG Bo 8469
28	12	15	15.05	+ 43	30	7.0	Boss 3229
29	12	15	15.22	+ 63	59	39.3	AG Hels 7139
30	12	16	26.16	+ 43	48	47.5	AG Bo 8491
31	12	16	44.70	+ 57	44	16.4	Boss 3234
32	12	17	18.43	+ 39	58	45.5	Boss 3235
33	12	19	2.81	+ 42	18	49.3	AG Bo 8510
34	12	19	39.10	+ 45	45	9.6	AG Bo 8514
35	12	21	43.99	+ 40	12	29.2	AG Bo 8531
36	12	21	50.38	+ 59	21	31.1	Boss 3260
37	12	21	56.32	+ 59	43	33.0	AG Hels 7186
38	12	22	35.28	+ 40	32	19.8	AG Bo 8537
39	12	23	52.55	+ 44	9	27.2	AG Bo 8548
40	12	25	0.76	+ 41	41	0.9	AG Bo 8557
41	12	25	18.37	+ 45	3	14.4	AG Bo 8561
42	12	25	30.54	+ 42	17	55.7	Boss 3270
43	12	25	44.99	+ 47	42	15.0	AG Bo 8565

*	α			δ			Authority
	<i>h</i>	<i>m</i>	<i>s</i>	<i>°</i>	<i>'</i>	<i>"</i>	
44	12	26	24.55	+ 47	57	44.3	AG Bo 8569
45	12	27	22.80	+ 40	38	19.2	AG Bo 8572
46	12	27	49.47	+ 41	32	23.5	AG Bo 8575
47	12	28	47.21	+ 47	38	2.2	AG Bo 8587
48	12	29	14.84	+ 39	38	23.8	AG Lu 5493
49	12	30	25.66	+ 41	49	40.3	Boss 3297
50	12	33	8.12	+ 41	31	49.6	AG Bo 8621
51	12	36	15.85	+ 45	3	4.3	AG Bo 8642
52	12	36	47.30	+ 40	13	13.1	Boss 3321
53	12	36	49.10	+ 59	38	17.5	AG Hels 7294
54	12	41	27.51	+ 39	18	44.8	AG Lu 5560
55	12	43	32.40	+ 63	55	42.3	AG Hels 7334
56	12	47	55.31	+ 39	15	16.2	Boss 3371

(5) Reduction of Observations and Comparison with Ephemeris.

Observations in Florence. *Ast. Nach.* 128.

The observations were made by Pons with a double ring micrometer whose inner and outer radii were 1406.6" and 1507.1" respectively. The original observations are given by him in full, noting the times of transit of the comet and the comparison stars across the edges of the rings. The names of the comparison stars are given only in two cases, namely on July 6 and 21. By the approximate ephemeris computed from Heiligenstein's elements, the comparison stars have all been identified except those on June 28. Reduction of observations was made with correction for refraction. The observations are very poor, the comparisons differing greatly one with another, even though made on the same night with the same star. In many cases with a transit of the comet, transits of two or more comparison stars were observed. In such a case, the probable error of the observed right ascension, provided the errors in the positions of the comparison stars are neglected, will be $\frac{1}{2} \sqrt{\varepsilon'^2 + \frac{\varepsilon^2}{n}}$, where ε' and ε are the probable errors of the observed times of transit for the comet and a star, and n is the number of the comparison stars observed at a time. It was found from the actual comparison that the ratio $\frac{\varepsilon'}{\varepsilon}$ is approximately 1.4. With this, the following weight was assigned to each place derived from a comparison star.

No. of stars	Weight	No. of stars	Weight
1	1.00	4	0.33
2	0.60	5	0.27
3	0.43	6	0.23

Weight for declination is more complicated, as it depends upon the distance of the path of comet and star from the centre of the ring. But for the sake of simplicity, the same weight as in the case of right ascension was assigned.

In the following table the times are corrected for aberration. The places previous to July 6 were computed directly from the elements, because the rapid motion of the comet makes the interpolation from the ephemeris very uncertain. Observations on June 28 were omitted.

No.	Greenwich M. T.		*	Red. ad l. app.		Comet—Star		Parallax		Obs.—Cal.		No. of Obs.	Wt.		
				in α	in δ	in α	in δ	in α	in δ	$\Delta\alpha \cos \delta$	$\Delta\delta$				
	1827			<i>s</i>	<i>"</i>	<i>m</i>	<i>s</i>	<i>s</i>	<i>"</i>	<i>s</i>	<i>"</i>				
1	June	20.51329	1	-2.34	-7.9	-13	31.22	-27	37.9	-1.91	+0.5	-2.81	+12.0	3	3.0
2		22.48441	2	+2.25	-9.1	-13	0.63	+30	46.1	-2.46	+0.6	+1.29	-15.8	2	2.0
3		22.51260	2	+2.25	-9.1	-11	53.64	+37	19.1	-2.72	+0.5	+5.85	-20.9	1	0.5*
4		29.42976	5	-0.52	+2.8	-4	33.00	+1	31.8	+2.62	+0.3	+2.98	-28.3	1	0.3
5		"	6	-0.58	+2.8	-5	47.80	-16	57.4	+2.62	+0.3	+2.83	-1.9	1	0.3
6		"	7	-0.58	+3.0	-9	5.81	-22	20.6	+2.62	+0.3	+3.23	-14.0	1	0.3
7		"	9	-0.47	+3.7	-25	6.41	-10	55.5	+2.62	+0.3	+2.38	+60.9	1	0.3
8	July	1.37254	8	+0.11	+2.9	+10	56.55	-40	20.8	+1.76	0.0	+4.21	+1.4	2	0.3†
9		"	10	+0.12	+3.1	+6	10.05	-40	25.4	+1.76	0.0	+4.16	-4.0	2	0.3†
10		"	11	+0.19	+3.4	+0	31.80	-17	41.9	+1.76	0.0	+4.43	+11.9	2	0.3†
11		"	13	+0.25	+3.8	-9	56.06	-10	47.3	+1.76	0.0	+4.08	+19.5	2	0.3†
12		2.39490	12	+0.36	+4.0	-9	15.30	-43	55.8	+1.56	+0.1	+5.44	-4.1	1	0.6
13		"	18	+0.50	+4.0	-10	22.92	-6	44.4	+1.56	+0.1	+6.50	+13.1	1	0.6
14		3.36799	17	+0.69	+3.5	-3	17.10	+38	7.5	+1.30	0.0	-1.66	-33.1	1	0.2
15		"	19	+0.71	+3.7	-8	2.60	+41	53.3	+1.30	0.0	-1.74	-22.8	1	0.2
16		"	23	+0.72	+4.3	-19	25.61	+0	34.3	+1.30	0.0	-0.41	-18.9	1	0.2
17		"	24	+0.73	+4.5	-23	25.11	-2	10.6	+1.30	0.0	+0.07	-32.9	1	0.2
18		"	29	+0.79	+4.6	-26	21.10	+36	16.0	+1.30	0.0	+0.35	-19.4	1	0.2
19		"	55	+0.94	+5.8	-54	40.35	+40	8.7	+1.30	0.0	-0.47	-22.5	1	0.2
20		4.42566	14	+0.72	+3.0	+7	4.82	-18	50.4	+1.23	+0.2	-0.06	+7.2	2	0.9
21		"	15	+0.73	+3.1	+5	36.34	-13	41.0	+1.23	+0.2	+0.29	+8.8	2	0.9
22		"	16	+0.75	+3.1	+4	37.99	-5	59.8	+1.23	+0.2	+0.11	+2.1	2	0.9
23		5.36761	37	+0.99	+3.2	-22	47.01	+28	16.8	+1.04	+0.1	+1.12	+11.6	1	0.6
24		"	53	+1.07	+4.9	-37	42.39	+33	21.1	+1.04	+0.1	-0.13	+2.4	1	0.6
25		6.37636	21	+0.96	+3.0	-0	13.52	+10	49.9	+0.97	+0.1	+0.61	+38.1	2	1.2
26		"	22	+0.98	+3.1	-3	56.02	+11	10.8	+0.97	+0.1	+1.65	-25.5	2	1.2
27		6.38879	21	+0.96	+3.0	-0	12.55	+8	11.4	+0.99	+0.2	-0.20	-33.9	1	0.4
28		"	22	+0.98	+3.1	-3	56.68	+9	7.4	+0.99	+0.2	-0.01	-62.4	1	0.4
29		"	31	+1.03	+3.6	-13	52.53	+25	9.4	+0.99	+0.2	-0.25	-23.5	1	0.4
30		12.36650	27	+1.23	+1.4	+2	14.69	+35	28.7	+0.63	+0.2	-0.97	-11.6	3	3.0
31		13.36372	27	+1.21	+1.4	+3	33.41	-39	2.0	+0.59	+0.2	-1.07	-6.6	1	1.0
32		13.36322	27	+1.21	+1.4	+3	32.41	-31	38.8	+0.60	+0.2	-2.02	-19.4	1	0.4
33		"	43	+1.28	+2.0	-8	45.05	-12	45.6	+0.60	+0.2	-0.29	+13.2	1	0.4
34		"	44	+1.27	+2.1	-9	25.33	-28	50.0	+0.60	+0.2	-0.78	-21.8	1	0.4
35		13.38274	27	+1.21	+1.4	+3	35.02	-40	30.4	+0.61	+0.2	-0.95	-12.3	1	0.3
36		"	43	+1.28	+2.0	-8	44.42	-14	11.4	+0.61	+0.2	-0.55	-13.9	1	0.3
37		"	44	+1.27	+2.1	-9	23.96	-29	36.8	+0.61	+0.2	-0.55	-9.9	1	0.3
38		"	47	+1.29	+2.1	-11	47.91	-9	45.7	+0.61	+0.2	-1.41	-0.9	1	0.3

DEFINITIVE ORBIT OF COMET 1827 II (PONS).

No.	Greenwich M. T.	*	Red. ad l. app.		Comet—Star		Parallax		Obs.—Cal.		No. of Obs.	Wt.
			in α	in δ	in α	in δ	in α	in δ	$\Delta\alpha \cos \delta$	$\Delta\delta$		
	1827		^s	["]	^m	^s	["]	^s	["]	^s	["]	
39	July 14.36026	26	+1.24	+ 1.0	+ 5 39.61	— 9 9.8	+0.56	+ 0.2	—1.45	— 9.7	1	0.6
40	" "	34	+1.29	+ 1.2	— 1 29.83	+34 28.3	+0.56	+ 0.2	—1.16	+ 4.6	1	0.6
41	15.35624	34	+1.27	+ 1.2	— 0 23.55	—31 16.3	+0.53	+ 0.2	+0.05	+18.7	1	0.4
42	" "	41	+1.31	+ 1.3	— 6 1.98	+10 38.7	+0.53	+ 0.2	+0.67	+18.6	1	0.4
43	" "	51	+1.36	+ 1.9	—17 0.23	+10 54.8	+0.53	+ 0.2	+0.16	+35.2	1	0.4
44	16.35823	28	+1.30	+ 0.4	+ 5 0.64	+40 46.1	+0.51	+ 0.2	+0.59	— 2.6	1	1.0
45	16.36892	28	+1.30	+ 0.4	+ 5 2.26	+39 59.5	+0.52	+ 0.2	+1.32	—10.4	1	0.4
46	" "	30	+1.30	+ 0.6	+ 3 50.85	+22 18.3	+0.52	+ 0.2	+1.10	+49.1	1	0.4
47	" "	39	+1.32	+ 1.0	— 3 35.68	+ 0 29.3	+0.52	+ 0.2	+1.02	—19.8	1	0.4
48	17.35524	28	+1.29	+ 0.4	+ 5 55.57	—18 17.9	+0.49	+ 0.2	+0.85	—15.4	1	1.0
49	17.37339	28	+1.29	+ 0.4	+ 5 54.53	—19 9.7	+0.51	+ 0.2	—0.57	— 4.7	1	0.6
50	" "	30	+1.28	+ 0.5	+ 4 42.60	—37 58.2	+0.51	+ 0.2	—1.17	—12.6	1	0.6
51	18.38357	42	+1.34	+ 0.7	— 3 30.72	— 3 3.2	+0.49	+ 0.2	—1.35	+10.7	1	1.0
52	18.39581	33	+1.32	+ 0.3	+ 2 57.59	— 4 35.7	+0.49	+ 0.2	—1.37	+11.3	2	1.2
53	" "	42	+1.34	+ 0.7	— 3 30.16	— 3 48.8	+0.49	+ 0.2	—1.37	+ 5.0	2	1.2
54	19.35129	49	+1.35	+ 0.8	— 7 36.06	—26 35.0	+0.45	+ 0.2	+1.42	—27.6	1	1.0
55	19.36153	40	+1.34	+ 0.4	— 2 15.20	—18 27.5	+0.46	+ 0.2	—1.97	—28.3	1	0.6
56	" "	49	+1.35	+ 0.8	— 7 40.84	—27 30.2	+0.46	+ 0.2	—2.51	—51.2	1	0.6
57	19.39126	46	+1.35	+ 0.6	— 4 58.52	— 9 26.1	+0.47	+ 0.2	+1.08	+87.6	1	0.3*
58	" "	50	+1.37	+ 0.9	—10 16.89	— 8 40.3	+0.47	+ 0.2	+1.29	+99.8	1	0.3*
59	20.37338	32	+1.34	— 0.4	+ 6 14.70	+33 35.5	+0.45	+ 0.2	—0.27	+ 2.5	3	1.0
60	" "	35	+1.35	— 0.1	+ 1 49.10	+20 7.0	+0.45	+ 0.2	—0.30	+18.0	3	1.0
61	" "	38	+1.34	0.0	+ 0 58.33	— 0 3.8	+0.45	+ 0.2	+0.09	— 2.1	3	1.0
62	" "	45	+1.36	+ 0.3	— 3 50.19	— 6 2.1	+0.45	+ 0.2	—0.65	— 0.7	3	1.0
63	20.38295	52	+1.40	+ 0.8	—13 12.71	+18 45.3	+0.45	+ 0.2	+0.57	+ 9.1	1	1.0
64	21.35433	48	+1.38	+ 0.2	+ 4 59.36	+ 6 59.4	+0.42	+ 0.2	+0.32	—11.0	1	1.0
65	21.36212	48	+1.38	+ 0.2	— 4 58.27	+ 6 29.6	+0.43	+ 0.2	+0.92	—19.1	1	0.4
66	" "	54	+1.43	+ 0.8	—17 10.97	+26 27.1	+0.43	+ 0.2	+0.94	0.0	1	0.4
67	" "	56	+1.46	+ 1.2	—23 39.96	+29 52.0	+0.43	+ 0.2	+0.05	— 3.3	1	0.4

* Weight 1/2.
† Observations with the inner ring omitted.

The observations on June 24 were made in the meridian, probably with a transit instrument. The times of transit over 5 vertical wires were noted for the comet and two comparison stars. On June 25, the times of transit over 4 wires were observed with the same instrument without any comparison star. But the reduction was made under the assumption that the error of azimuth for each wire was the same as on the previous day.

No.	Greenwich M. T.	*	Red. ad l. app.		Comet—Star		Parallax		Obs.—Cal.		Wt.
			in α	in δ	in α	in δ	in α	in δ	$\Delta\alpha \cos \delta$	$\Delta\delta$	
1	1827 June 24.38723	3	+1.67	—10.0	+18 56.10	—	0.00	—	—1.80	—	1.0
2	" "	4	+1.07	— 9.8	—12 1.40	—	0.00	—	—1.88	—	1.0
3	25.46303	—	—	—	—	—	0.00	—	+0.08	—	1.0

Observations in Nimes. *Ast. Nach.* 148.

The following observations were made by Valz, and only the observed differences in right ascension and declination are given. A filar micrometer was probably used.

No.	Greenwich M. T.	*	Red. ad l. app.		Comet--Star		Parallax		Obs.--Cal.		Wt.
			in α	in δ	in α	in δ	in α	in δ	$\Delta\alpha \cos \delta$	$\Delta\delta$	
1	1827 July 5.58192	20	+ 1.18	+ 5.9	+ 0 17.73	+ 13 44.0	+ 0.72	- 0.6	- 3.45	- 26.5	0.3
2	" "	25	+ 0.98	+ 3.6	- 12 33.00	+ 56 22.0	+ 0.72	- 0.6	- 3.04	+ 42.0	0.3
3	" "	36	+ 1.00	+ 4.1	- 21 57.00	+ 24 8.0	+ 0.72	- 0.6	- 2.60	+ 17.8	0.3
4	" "	37	+ 0.99	+ 3.2	- 22 0.53	+ 1 34.0	+ 0.72	- 0.6	- 1.39	- 15.2	0.3

(6) Normal Places.

By grouping the observations, the following normal places were obtained.

Date	α (true)	δ (true)	O-C $\Delta\alpha \cos \delta$	Wt.	O-C $\Delta\delta$	Wt.	Dates included
1827 June 21.5	$h \quad m \quad s$ 2 40 43.77	$^{\circ} \quad ' \quad ''$ + 70 16 3.6	$''$ - 11.4	— 8.5	$''$ - 1.1	5.5	June 20-22
July 1.0	11 27 29.50	+ 70 36 50.2	+ 65.2	3.6	+ 5.3	3.6	June 20-25
5.5	11 59 40.91	+ 59 55 22.3	- 0.7	9.9	- 3.3	9.9	June 29-July 2
13.5	12 17 10.67	+ 47 19 47.4	- 12.7	8.8	- 4.3	8.8	July 3-6
18.0	12 21 44.00	+ 42 35 43.3	- 4.8	10.6	- 0.9	10.6	July 12-15
20.5	12 23 40.84	+ 40 26 9.6	+ 1.0	7.2	+ 0.9	7.2	July 16-19
							July 20-21

It will be noted that the normal place for July 1.0 is very uncertain. It was built from the observations on June 29, July 1 and 2. On June 29 and July 2, transits of the comet were observed only once each day, and the observations on July 1 are very doubtful. The comet did not approach near enough to any planet to receive appreciable perturbation from it.

(7) Least Square Solution for Definitive Orbit.

In computing the differential coefficients for the equations of condition, the elements previously used were referred to the equator. They thus become :

Equatorial Elements.

$T = 1827 \text{ June } 7.10260 \text{ Greenwich Mean Time.}$

$\omega' = 346^{\circ} 29' 25''.96$
 $\varrho' = 290 \quad 59 \quad 31.42$
 $\pi' = 277 \quad 28 \quad 57.37$
 $i' = 150 \quad 9 \quad 32.80$

}

1827.0

$\log q = 9.906549$

$\log e = 9.974730$

DEFINITIVE ORBIT OF COMET 1827 II (PONS).

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The differential coefficients were checked by independent duplicate computation. The logarithmic equations of condition are as follows :

Equations of Condition.

α										Wt.	
June 22.5	- 11.4	= [8.16571 _n]	ΔT	+ [7.91251]	Δe	+ [0.59103 _n]	$\Delta \log q$	+ [8.53720 _n]	$\sin i' \Delta \varrho' + [9.91694] \Delta A + [8.82056] \Delta i'$	8.5	
July 1.0	+ 65.2	= [8.06009 _n]		+ [9.20314]		+ [0.34230]		+ [9.49916 _n]	+ [8.70649 _n]	+ [9.20533]	(3.6)
5.5	- 0.7	= [7.60371 _n]		+ [9.15711]		+ [0.36826]		+ [9.43844 _n]	+ [9.52549 _n]	+ [9.10100]	9.9
13.5	- 12.7	= [6.82565]		+ [9.14114]		+ [0.32964]		+ [9.38211 _n]	+ [9.70427 _n]	+ [9.01363]	8.8
18.0	- 4.8	= [7.25211]		+ [9.14600]		+ [0.30541]		+ [9.35990 _n]	+ [9.73813 _n]	+ [8.98204]	10.6
20.5	+ 1.0	= [7.34202]		+ [9.15081]		+ [0.29302]		+ [9.34927 _n]	+ [9.75046 _n]	+ [8.96687]	7.2
δ											
June 21.5	- 1.1	= [8.67413 _n]	ΔT	+ [9.25845]	Δe	+ [9.89284 _n]	$\Delta \log q$	+ [9.09897]	$\sin i' \Delta \varrho' + [0.15449] \Delta A + [8.76493] \Delta i'$	5.5	
July 1.0	+ 5.3	= [8.36695]		+ [8.99218 _n]		+ [0.38085]		+ [9.78205]	+ [9.99478 _n]	+ [9.66413 _n]	(3.6)
5.5	- 3.3	= [8.20459]		+ [8.92310 _n]		+ [0.19859]		+ [9.83398]	+ [9.83633 _n]	+ [9.77073 _n]	9.9
13.5	- 4.3	= [7.87423]		+ [8.65852 _n]		+ [9.92814]		+ [9.77961]	+ [9.55115 _n]	+ [9.83070 _n]	8.8
18.0	- 0.9	= [7.69139]		+ [8.46778 _n]		+ [9.79584]		+ [9.72622]	+ [9.40615 _n]	+ [9.84012 _n]	10.6
20.5	+ 0.9	= [7.59083]		+ [8.34076 _n]		+ [9.72724]		+ [9.69427]	+ [9.33083 _n]	+ [9.84234 _n]	7.2
$\Delta = \pi' - 2 \varrho'$											

$$\Delta = \pi' - 2\varrho'$$

Each equation of condition was multiplied by the square root of its weight, and rendered homogeneous by the introduction of the new unknown quantities such that :

$$\begin{aligned} x &= [9.04431] \Delta T \\ y &= [9.65866] \Delta e \\ z &= [1.05574] \Delta \log q \\ t &= [0.33180] \sin i' \Delta \varrho' \\ u &= [0.52467] \Delta A \\ w &= [0.35278] \Delta i' \end{aligned}$$

$$\text{Unit of error} = [2.09240]$$

With these substitutions, the following normal equations were obtained. Normal place for July 1.0 was omitted.

Normal Equations (natural numbers).

+ 1.44471 x	- 1.31862 y	+ 0.81914 z	+ 0.68454 t	- 1.71018 u	- 0.87443 w	=	+ 0.05507
- 1.31862 x	+ 4.84594 y	+ 1.53253 z	- 2.22772 t	- 0.11352 u	+ 1.64629 w	=	- 0.35223
+ 0.81914 x	+ 1.53253 y	+ 2.59150 z	+ 0.09224 t	- 2.26893 u	- 0.61498 w	=	- 0.03352
+ 0.68454 x	- 2.22772 y	+ 0.09224 z	+ 3.21842 t	- 0.52273 u	- 3.07566 w	=	- 0.02063
- 1.71018 x	- 0.11352 y	- 2.26899 z	- 0.52273 t	+ 2.91130 u	+ 1.08444 w	=	+ 0.07470
- 0.87443 x	+ 1.64629 y	- 0.61498 z	- 3.07566 t	+ 1.08444 u	+ 3.25149 w	=	+ 0.08469

From these the elimination equations were found. They are given below.

S. OGURA :

Elimination Equations (natural numbers).

+ 1.44471 <i>x</i>	- 1.31862 <i>y</i>	+ 0.81914 <i>z</i>	+ 0.68454 <i>t</i>	- 1.71018 <i>u</i>	- 0.87443 <i>w</i> =	+ 0.05507
+ 3.64241 <i>y</i>	+ 2.28018 <i>z</i>	- 1.60292 <i>t</i>	- 1.67445 <i>u</i>	+ 0.84819 <i>w</i> =	- 0.30197	
	+ 0.69963 <i>z</i>	+ 0.70754 <i>t</i>	- 0.25112 <i>u</i>	- 0.65018 <i>w</i> =	+ 0.12429	
		+ 1.47315 <i>t</i>	- 0.19532 <i>u</i>	- 1.63053 <i>w</i> =	- 0.30530	
			+ 0.00107 <i>u</i>	- 0.01029 <i>w</i> =	+ 0.00520	
				+ 0.01677 <i>w</i> =	+ 0.01594	

An inspection of these equations shows that the coefficients of the last two unknowns *u* and *w* are very small, and their determination is therefore attended with considerable uncertainty. The first four unknowns were first expressed in terms of *u* and *w*, and later in terms of *w* alone (Oppolzer : Bahnbestimmung, Bd. II, p. 326-370).

$$\begin{aligned}x &= [0.77431] + [1.11919] w \\y &= [0.14347] + [0.59492] w \\z &= [0.16575] + [0.28612] w \\t &= [9.63153] + [0.37262] w \\u &= [0.68050] + [0.97496] w\end{aligned}$$

The substitution of these values gives for the corrections to the elements with their mean errors the following values :

$$\begin{aligned}\Delta T &= + 0.089822 \pm 0.061737 \\ \Delta e &= + 0.0060184 \pm 0.0044522 \\ \Delta \log q &= + 0.0001597 \pm 0.0009074 \\ \Delta \varpi' &= + 4' 30''.39 \pm 3' 44''.06 \\ \Delta \Lambda &= + 7' 39''.18 \pm 5' 4''.16 \\ \Delta i' &= + 0' 44''.39 \pm 43''.82\end{aligned}$$

If the above values are adopted, the ecliptic elements would be as follows.

Definitive Orbit.

T = 1827 June 7.192422 Greenwich Mean Time.

$$\left. \begin{aligned}\omega &= 19^{\circ} 18' 56''.12 \\ \varpi &= 317 \quad 39 \quad 39.67 \\ \pi &= 336 \quad 58 \quad 35.79 \\ i &= 136 \quad 26 \quad 11.00\end{aligned} \right\} 1827.0$$

$$\log q = 9.9067087$$

$$\log e = 9.9774915$$

$$\text{Period} = 63.830 \text{ years}$$

The equatorial coordinates are

$$x = [9.9473120] r. \sin (\tau + 142^{\circ} 45' 0''.75)$$

$$y' = [9.9929448] r. \sin (\tau + 238^{\circ} 12' 53''.21)$$

$$z = [9.6967115] r. \sin (\tau + 346^{\circ} 41' 35''.54)$$

The normal places were recomputed with these elements, and the residuals (obs.—cal.) were compared with those obtained by substituting the corrections to the elements in the equations of condition. The results are shown in the following table.

Date	Elements		Equation	
	$\Delta \alpha. \cos \delta$	$\Delta \delta$	$\Delta \alpha. \cos \delta$	$\Delta \delta$
1827	"		"	
Junc 21.5	—	+ 1.0	—	— 0.4
22.5	+ 0.8	—	+ 0.7	—
July 1.0	(+ 66.9)	(+ 9.2)	(+ 66.0)	(+ 9.5)
5.5	+ 4.6	+ 1.9	+ 3.8	+ 1.3
13.5	— 6.3	— 1.9	— 7.0	— 1.9
18.0	+ 0.5	+ 0.2	— 0.4	0.0
20.5	+ 5.3	+ 1.2	+ 4.4	+ 1.0

(8) Remarks.

The least square solution including the normal place for July 1.0 was made, and the following corrections were obtained.

$$\Delta T = -0.078352$$

$$\Delta e = -0.0062477$$

$$\Delta \log q = -0.0000622$$

$$\Delta \vartheta' = -6' 20''.32$$

$$\Delta \Lambda = -5' 55''.46$$

$$\Delta i' = -1' 26''.14$$

If we adopt these elements, the residual in right ascension for July 1.0 is reduced from 65'' to 50'', but the residuals for other days increase generally, reaching more than 10'' each for two of them.

It will be noted from the equations of condition which determine the value of w that variations of w by ± 0.5 , which correspond to the variations of $\pm 27''.5$ for i' , will not contradict the observations. Variations of w by ± 0.5 make $\log q$ and e vary by ± 0.000051 and ± 0.002589 respectively. From which it follows :

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Δw	+0.5	-0.5
Period in years	69.06	59.21

Thus we see that the period is uncertain by about 10 years.

The aphelion distance of this comet is 31.1 astronomical units, and its orbit extends a little beyond the orbit of Neptune, whose mean distance from the Sun is 30.1. The orbit cuts the ecliptic at a point a little within the earth's orbit, and at a point between the orbits of Saturn and Uranus, the heliocentric distances of the comet at the ascending and descending nodes being 0.83 and 15.1 respectively. The orbit of the comet does not approach within four astronomical units of the orbit of Neptune. It approaches the orbits of Saturn and Uranus a little within one astronomical unit.

The orbit somewhat resembles that of a comet which appeared in 1500. The orbit of the latter was determined by Hind from Chinese observations (*Par. Bull.* 1861 Aug. 9), the elements of which are shown below, with those of the second comet of 1827 referred to the mean equinox of 1500.0.

Comet	1500	1827 II
T	1500 May 17	1827 June 7.19 G. M. T.
ω	20°	19° 21'
Q	310	313 . 8
i	105	136 24
q	1.40	0.8067
e	1.00	0.9495
Period		63.83 years

The interval between two perihelion passages is 327.01 years, and one fifth of this interval (65.40 years) comes very near to the period found for the comet 1827 II. Ephemerides for the year 1500 were calculated on the basis of the elements of the comet 1827 II, giving various values for T , but none of them satisfy the observations (J. Williams : *Chinese Comets*, p. 81). So it cannot be considered that the two comets are identical.

Tokyo, March 1917.

ON THE ORBITS OF TWO COMETS OBSERVED IN JAPAN.

By

S. Ogura.

Some of the astronomical records which appear in Japanese history have been introduced to European astronomers, or discussed by Kaempfer¹⁾, Knobel²⁾, K. Hirayama³⁾ and the present writer⁴⁾ &c. The records are comparatively recent, none of them being found as far back as the 6th century, and most of them are very simple. But the records are numerous and will serve to verify and complete the records of other nations. The comet has been known to Japanese as Hahakibosi or Hôkibosi, the besom-star, from its appearance. The earliest record of a comet, as far as I am aware, is that in Nihonsyoki (日本書紀), or Nihongi (日本紀), to this effect: "In the 6th year of the Emperor Zyomei (舒明), and the 8th month, a long star was seen in the south. The people of that time called it a besom-star." This year is A. D. 634. After this date, numerous apparitions of comets are recorded in Japanese history, some of them not being recorded by other nations. Among them, Prof. K. Hirayama pointed out that the apparition of Halley's comet in A.D. 912 was recorded only in Japan. Among the records of comets, the two following are precise enough to enable us to determine their orbits.

(1) Comet of A. D. 1132.

In *Tyûyûki* (中右記), a diary written by Hudiwara-no-Munetada (藤原宗忠), the following records are to be found.

天承二年八月廿五日 The second year of the epoch Tensyô⁵⁾, the 8th month,
壬子夜曉寅刻、彗星 the 25th day⁶⁾, Nidunoe-Ne, at night. At the hour of Tora⁷⁾
見于北方、長三尺、 in the early morning, a comet appeared in the north. It was

1) *History of Japan*, 1728. 2) On the Astronomical Observations recoded in the Nihongi, the ancient Chronicle of Japan. *Monthly Not.*, vol. 66, p. 67. 3) Halley's Comet in Japanese History. *Observatory*, vol. 33, p. 130. Historical Records of the Leonids (in Japanese). *Astron. Herald*, vol. 5, p. 61. 4) On the ancient Eclipses recorded in Japan (in Japanese). *Astron. Herald*, vol. 9, p. 13. 5) A.D. 1132. 6) Oct. 5 in the Julian Calendar. 7) 4 a.m. The observed time is 4 o'clock in the morning of Oct. 6.

其色白、尾指西、
在觜度、近入敷星、
同廿六日夜、天陰
不見、廿七日夜亥刻、
見寅方、與婁第三
星相近、長三丈餘、
光芒殊盛、尾指戌亥、
廿八日夜、南行、其
光衰微、長一丈餘、
芒氣相及奎宿、廿
九日夜、在同座、
猶南行、與土司空星
相並、芒角減少、長二
三尺所、卅日夜、九月
一日夜、其天陰不
見、二日夜以後、消
不見、

3 feet in length, and its colour was white, and the tail pointed to the west. The comet was in the sidereal division Si¹⁾, and approached the star Nyûsiki-sei²⁾. The night of the 26th day was cloudy and the comet was not seen. On the night of the 27th day³⁾, at the hour of I⁴⁾, the comet was seen in the direction of Tora⁵⁾, and was near the third star⁶⁾ of Rô. It was more than 30 feet in length, and was specially bright, the tail pointing to the north-west. By the night of the 28th day, the comet had moved to the south. Its light faded away. Its length was more than 10 feet and the tail reached the sidereal division Kei⁷⁾. On the night of the 29th day⁸⁾, the comet was in the same constellation and moved further south. It was by the side of Dosikû-sei⁹⁾. The tail became shorter, and its length was 2 or 3 feet. On the nights of the 30th day of the 8th, and the 1st day¹⁰⁾ of the 9th month, the sky was cloudy and the comet was not seen. On the night of the 2nd day, the comet disappeared, and it was not seen again.

Observations were made in Kyôto. The observation on the 25th day gives the right ascension of the comet fairly accurately, the sidereal division of Si having the breadth of only two and a half degrees in right ascension. The declination is uncertain, there being no star of any such name as Nyûsiki-sei, or Siki-sei. But by the inspection of the record, describing how the comet appeared in the north, as well as by the names of the oriental costellations, it is very probable that Nyûsiki-sei is a mistake for Hatikoku-sei (八穀星), the characters for which resemble those of Nyûsiki-sei (入敷星). Hatikoku-sei consists of δ , &c. Aurigæ and stars of Camelopardus. On the 29th day, the time of observation is not given. β Ceti rises on that day at about 7 p.m., and it seems probable that the observation was made about the same time as on the 27th day, i.e. at 10 p.m. Thus we have the following data:—

Greenwich M. T.			α		δ
Oct.	d	h	h	m	
	5	7	4	52	+ 60°.0
	7	1	1	19	+ 19.1
	9	1	0	0	— 22.8

1) Area defined by the two hour circles passing through λ and ζ Orionis. 2) We cannot identify this star.

3) Oct. 7. 4) 10 p.m. 5) E 30° N. 6) α Arietis. 7) Defined by β , δ , ϵ , &c. Andromedæ and stars of Pisces.

8) Oct. 9. 9) β Ceti. 下司空星 in the manuscripts, but it must be a mistake for 土司空星. 10) Oct. 11.

Places are referred to the equinox of 1132.0. The motion of the comet was exceedingly rapid, moving about 100° in four days. The comet must have come very near to the earth.

From the above data, the following elements were obtained.

$$\begin{aligned} T &= 1132 \text{ Aug. } 30.20 \text{ Greenwich M. T.} \\ \left. \begin{aligned} \omega &= 114^\circ.3 \\ \varrho &= 201.1 \\ i &= 106.4 \end{aligned} \right\} 1132.0 \\ \log q &= 9.8666 \end{aligned}$$

The computed place for the middle observation coincides with the observation within 4° . The elements must be uncertain by many degrees, except the value of ϱ , which is determined pretty accurately. Owing to the uncertainty of the declination for the first observation, two other sets of elements were determined giving for the declinations $+50^\circ$ and $+70^\circ$. In these cases, the computed places for the middle observation differed from the observation by 16° and 15° respectively.

There are many other records of this comet in Japan. They are found in Hyakurensyô (百鍊抄), Itidaiyôki (一代要記), Zyûsandaïyôryaku (十三代要略), but they are very simple, giving only such particulars as that the comet was seen in the north. This comet was also observed in China¹⁾. In the reign of Kaou Tsung (高宗) of Sung (宋) dynasty, the second year of the epoch Shaou Hing (紹興), the 8th month, on the day Kea Yin (甲寅), the comet was seen in Wei²⁾ (胃). It disappeared on the day Kea Seuh (甲戌), in the 9th month. The day of Kea Yin was Oct. 7, and so it confirms the Japanese observations. The day Kea Seuh was Oct. 27. Williams considered the day Kea Yin to be August 14, and the day Kea Seuh Sept. 3, but he was mistaken. The comet was also observed in Europe.³⁾

This comet did come very near to the earth, the nearest approach to the earth was about 0.045 of an astronomical unit on Oct. 7. If the materials of which the comet consisted had been scattered along the orbit, the people would have observed, about Oct. 7 (Oct. 14 in the Gregorian Calendar), the display of a meteoric shower, coming from a point near to θ Ursæ Majoris ($\alpha=148^\circ$, $\delta=+52^\circ$ for the equinox of 1900.0).

1) Williams: *Chinese Comets*, p. 61.

2) Sidereal division defined by 35, 39, 41 Arietis.

3) Pingré: *Cométo-*

graphie, I p. 392.

(2) Comet of A. D. 1240.

In Adumakagami (吾妻鏡), a diary in which the events relating to the Kamakura Government are written, the following records are found.

延應二年正月二日丁卯、戌刻彗星出現申方、芒氣三尺指辰巳方、色白赤、(中略)、此去年十二月晦夜出現、人々見之、四日己巳、戌刻申方彗星出現、芒氣四尺指巽方、色白赤、赤色少、本大如鎮星、六日辛未、入夜陰、彗星不現、七日壬申、戌刻彗星現歲星傍(相去三尺餘所)、芒氣指艮方、光芒五尺、軸星大如太白、八日癸酉、戌刻彗星近歲星(相去二尺餘所)、今日被始行天變御祈護摩、九日甲戌、彗星透雲間芒氣不明、十日乙亥、雨降、辰刻雷鳴、今夜彗星不現、十一日丙子、戌刻彗星犯壁一星(相去二尺所)、(中略)、十八日癸未、彗星近奎、(中略)、十九日甲申、彗星

The second year¹⁾ of the epoch En-ô, the first month, the 2nd day²⁾, Hinoto-U. At the hour of Inu³⁾, a comet appeared in the direction of Saru⁴⁾. The tail was 3 feet in length, and pointed to the south-east. The colour was white-red. . . . This comet also appeared on the night of the last day⁵⁾ of the 12th month of last year, when many people saw it. On the 4th day⁶⁾, Tutinoto-Mi, at the hour of Inu, the comet appeared in the direction of Saru. The tail was 4 feet long and pointed to the south-east. Its colour was white-red, the red not being conspicuous. The head was as big as Saturn. On the 6th day, Kanoto-Hituzi, the night was cloudy and the comet did not appear. On the 7th day⁷⁾, Midunoe-Saru, at the hour of Inu, the comet appeared by the side of Jupiter (the distance between them was about 3 feet). The tail pointed to the north-east, and its length was 5 feet. The head was as big as Venus. On the 8th day, Midunoto-Tori, at the hour of Inu, the comet came near to Jupiter (distance about 2 feet). To-day the prayer for the heavenly evil was performed for the first time. On the 9th day, Kinoe-Inu, the comet was not seen distinctly through the cloud. The 10th day, Kinoto-I, was rainy; it thundered at the hour of Tatu⁸⁾, and the comet did not appear that night. On the 11th day⁹⁾, Hinoe-Ne, at the hour of Inu, the comet approached the first star¹⁰⁾ of Heki (the distance between them was about 2 feet). . . . On the 18th day¹¹⁾, Midunoto-Hituzi, the comet approached near to Kei¹²⁾. . . . On the 19th day, Kinoe-Saru, the

1) A. D. 1240. 2) Jan. 27 in the Julian Calendar. 3) About 8 p.m. 4) W. 30°S. 5) Jan. 25. 6) Jan. 29. 7) Feb. 1. 8) About 8 a.m. 9) Feb. 5. 10) γ Pegasi. 11) Feb. 12. 12) Sidereal division defined by β, ε, &c. Andromedæ, and stars of Pisces.

入奎中、(中略)、廿日
乙酉、戌刻彗星出現、
自去十七日至今夜光
芒次第盛也、廿六日
辛卯、戌刻彗星出現、
犯王良第五星、光芒
微薄、(中略)、二月六
日辛丑、入夜彗星出
現、自正月四日至今
日不消沒、十四日己
酉、天文道等終夜雖
窺見、彗變既入內天、

comet entered Kei On the 20th day, Kinoto-Tori, at the hour of Inu the comet was seen. From the 17th to the 20th, its light became more and more glorious every night. On the 26th day¹⁾, Kanoto-U, at the hour of Inu, the comet appeared and approached the 5th star²⁾ of Ôryô, and the light was faint. . . . On the 6th day³⁾, Kanoto-Usi, of the second month, the comet appeared in the night. From the 4th day of the first month to the present day, the comet does not disappear. On the 14th day,⁴⁾ Tutinoto-Tori, the astronomers watched the sky throughout the night, but the comet had already disappeared.

This is one of the most accurate records of a comet in Japan. The places of the comet are given pretty accurately on four days, i.e., on Feb. 1, 2, 5, and 20. From the observations on Feb. 2 and 5, we see that the comet was moving northwards about 5° a day at that time. On Feb. 1 and 2, the comet was near to Jupiter, the distances from it being 3 feet and 2 feet respectively. So it is very probable that the comet was about 2° north of Jupiter on Feb. 2. The place of Jupiter on this day was found to be $\alpha = 23^h 32^m 9^s$, $\delta = -4^\circ.0$ (equinox for 1240.0). The apparition of the comet is also recorded in Heikoki (平戸記), Hyakurensyô (百鍊抄), Hôdyôkudaiki (北條九代記), Itidaiyôki (一代要記) &c., in a more simple manner. This comet was also observed in China and in Europe⁵⁾. According to Chinese observations⁶⁾, the comet appeared on Jan. 31 in Ying Shih (營室)⁷⁾. On Feb. 23, the comet approached the second star⁸⁾ of Yuh Lang (王良), and it disappeared by March 31. There is a discrepancy of about 4° in declination between the Japanese observation on Feb. 20 and the Chinese observation on Feb. 23. So I have assumed that the mean of these two observed places is the probable place corresponding to the mean of observed times. Thus we have the following three observations for determining the orbit. The places are referred to the equinox of 1240.0.

1) Feb. 20. 2) λ Cassiopeiæ. 3) March 1. 4) March 9. 5) Pingré: *Cométographie*, I p. 403. 6) Williams: *Chinese Comets*, p. 63. Some mistakes have been corrected. 7) Sidereal division defined by α and β Pegasi. 8) κ Cassiopeiæ.

Greenwich M. T.		α		δ
	$^{\circ}$	$^{\text{h}}$	$^{\text{m}}$	$^{\circ}$
Feb.	1	23	23	33
	4	23	23	34
	21	12	23	52
				+ 54.5

The elements of the comet have been computed from these three observations, and the following values obtained.

$$\begin{aligned}
 T &= 1240 \text{ Jan. } 21.06 \text{ Greenwich M. T.} \\
 \omega &= 331^{\circ}.3 \\
 \varrho &= 124.5 \\
 i &= 75.4
 \end{aligned}
 \left. \vphantom{\begin{aligned} \omega \\ \varrho \\ i \end{aligned}} \right\} 1240.0$$

$$\log q = 9.8246$$

The elements somewhat resemble those of comet 1863 IV.

According to the above elements, the comet at the time of the first apparition, Jan. 25, was near to β Sculptoris ($\alpha=23^{\text{h}} 11^{\text{m}}$, $\delta=-43^{\circ}$, equinox for 1240.0), and on Feb. 5 it was about 2° north of γ Pegasi. The minimum distance from the earth was about 0.36 on Feb. 2.

Tokyo, April 1917.