Three Revolutions of the Comets Halley and Olbers 1759–2024

By HANS QVADE RASMUSEN

Det Kongelige Danske Videnskabernes Selskab
Matematisk-fysiske Meddelelser **40**:4

Kommissionær: Munksgaard
1979

Synopsis

The basis elements and the perturbed motion of the periodic comets Halley and Olbers during their two preceding revolutions and the present one have been computed; ephemerides for their coming return are derived. A non-gravitational effect has been taken into account, and it is shown that in addition to this the comets have been perturbed by other, unknown forces.

HANS QVADE RASMUSEN
Værslevgaard
DK-400 Kalundborg
Denmark

Contents

Printed in Denmark by Bianco Lunos Bogtrykkeri A/S. ISSN 0023-3323. ISBN 87-7304-083-5

I. Introduction

The problem of the origin of non-gravitational forces and their influence on the motion of comets might be solved by orbits computed in strict accordance with the law of gravitation for periodic comets with longer periods, 60 to 76 years, because these comets remain near the Sun only for a short time compared with the length of their revolution, so that a non-gravitational effect near the Sun can be estamated after a long period of accumulation.

On the other hand, if there is an effect originating in an unknown mass far from the Sun, this might be recognized as a slowly perturbation in the varying elements of long periodic comets, which coulrd hardly be realized in the case of short periodic comets moving nearer to the Sun.

Among the 67 periodic comets known for more than one revolution, only 5 have orbits of this dimension, and only 3 of them, comet Hallay and the periodic comets Pons-Brooks and Olbers, have been observed sufficiently for accurate orbit determination.

The orbit of comet Halley has been investigated by several independant computers, while for comet Pons-Brooks there is no definitive computation. The orbit of periodic comet Olbers has been investigated by Bessel(1) and Ginzel(2) but only for the first revolution. A repetition of Ginzel's computation including the second revolution has been carried out by myself and published in two papers(3). The second of these investigations reproduces the time of perihelion 1818, 1887 and 1956 fairly well, provided the mass of Jupiter is given a correction og -0.34 per cent. It is also shown that just the same correction to the Jupiter mass will bring the orbit of comet Halley computed by Cowell and Crommelin(4) into accordance with the recognized time of perihelion in 1759, 1835 and 1910.

However, this correction to the mass of Jupiter can not be accepted. But then the elements drived for comet Olbers, and the semi-major axis in particular, are not correct and must be improved using the usual mass of Jupiter. This will be done in the present paper, which also includes the predicted ephemeris for the next return in 2023–2024.

The salient point of the investigation is the fact, that residuals in positions at the apparitions before and after those returns, which are used to fix the orbit orientation, might indicate that forces not originating in the Sun and the 9 planets must perturb the orbit, provided the residuals can not be eliminated by changing the comet's length in the orbit. This is because a Solar pressure would push in the direction of the radius vector and could not change the inclination of the comet's orbit.

II. Comet Halley

The present orbit computation for comet Halley is based on Bobone's alements and his normal places for the 1910 return[5] and on the normal places for the preceding return in 1835 given by Westphalen[6]. Both sets are reduced to the equinox of 1950.0 and are given in Tables 1 and 2 together with the geocentric distances T of the comet and the corresponding Solar coordinates interpolated from Herget's table[7].

The improvement of the elements for 1910 is done by runs of integrations back to 1835 where the integrated time of perihelion for 1835 was compared with Westphalen's T. The improvement of the semi-major axis in 1910 has been done provisionally by the integral:

$$da = \frac{k}{3\pi\sqrt{a}}\,(T\text{ integrated} - T\text{ Westphalen})$$

da has been multiplied with each of the coefficients for this element in the equations of condition for 1910, and the products subtracted from the residuals on the right hand side. Then a least square solution repeated twice leads to the preliminar elements IV (Table 5).

Among several repeated integrations and solutions by least squares using the equations of condition for both apparitions the elements Va were chosen as basis for further computations. In this solution the inapplicable coefficients to dT for 1910 in the equations for 1835 have been ignored. A correction of the elements Va by least squares using the residuals from the 1910 return only but without any further correction of the semi-major axis gives the elements Vb. Both sets of elements are shown in Table 5.

Both orbits were integrated back to 1759 and forwards to 1986. The resulting elements, coordinates, velocities and perturbations are shown in Tables 5, 9, 10 and are almost identical for the two orbits. The residuals to the normal places are given in Tables 8. The residuals 14 to 20 in 1835 apparently are somewhat large, but only because here the comet's geocentric distances, shown in Table 2 are less than 0.25 A.U. As a further check the elements for J.E.D. 2391500.5 in 1835, derived from integration Vb were improved by the residuals and equations of condition only for 1835. But here the value of the semi-major axis of integration Vb in 1835 was adopted. The resulting elements Vc are shown in Table 5 and the final residuals for 1835 are seen in Table 8. The latter are smaller than those of Va and Vb, and much like Westphalen's residuals, which in his paper are given with opposite sign as c-o. However, the integration back to 1759 for these elements gives practically the same result as Va and Vb, and is not published.

A few words should be said about the equations of condition given in Tables 3 and 4. The method described by Stracke[8] has been chosen even if it requires the use of the equatorial values of the elements ω, Ω, i. The method, however, has certain advantages. When a comet moves fast near its perihelion in an extremely eccentric orbit, the differential coefficients expressed in the polar coordinate system are less sensitive for second order errors than the vector coefficients in the Cartesian system. Moreover, if arranged in Cracowian matrixes, Stracke's method is quite as simple as those described by Banachiewicz and Herget. In the least squares solution the weights given by Bobone have been slightly altered. So the numbers 16 to 19 have got their weights reduced to half the value, because at this time the distance of the comet from the Earth is less than half a unit. This fact, together with the elongation distance from the Sun, produces phase angles, which give some systematic errors in the observations.

The perturbed motion of the comet has been computed by Cowell's method, arranged in a suitable programme for simultaneous electronic integration of the coordinates of the comet orbits Va and Vb and 9 major planets, done by Ole Møller at the Aarhus University. The basis coordinates and velocities for the comet and planets are given in Table 12. The latter are derived by integration in the barycentre S_1 from the values given by Schubarth and Stumpff[9]. The coordinates and velocities for Mercury are derived from Duncombe's table[10]. The planetary masses are those given by Clemence[11].

As comet Halley approaches Mercury in 1835 and 1910, the perturbation from this planet has been accurately taken into account in the region of perihelion by using half a day step integration. But the long run through the outer orbit has been calculated by neglecting the direct integration of Mercury's motion and attraction on the comet, the Sun and the planets. Instead the mass of Mercury has been added to that of the Sun. This requires that, on the dates of change over, the coordinates and velocities of all the bodies get a reduction from the heliocentric origo S_0 to the barycentric S_1 and vice versa[12] by:

$$d\boldsymbol{r} = -m_1\boldsymbol{r}_1 : (1+m_1) \qquad \frac{d\boldsymbol{r}}{dt} = -\frac{d\boldsymbol{r}_1}{dt} : (1+m_1)$$

Then the integration step can be increased to 4 days, and the total number of integrations for each of the 11 bodies is reduced to about 22000.

III. The Effect of Non-Gravitational Forces on Comet Halley

In Table 9 are given the osculating elements at different epochs within the integrated periods, and here the elements Va and Vb in columns 1 and 2 show that the integrated time of perihelion in 1759 is T = J.D. 2363588.25. However, the elements derived by Rosenberger from observations of that apparition give the periheliontime T = J.D. 2363592.55 which is $4^{d}.30$ later than the integration shows. This means that the elements of 1835 must have their osculating period diminished by $4^{d}.30$ in order to reproduce the observations of 1759. But in that case a further forward integration from 1835 with the same reduced period and the corresponding semi-major axis will show an integrated T in 1910 to be the same $4^{d}.30$ too early, i.e. the increase of the period has been confirmed.

If this phenomenon should be a result of the Solar effect on the comet, it will not be correct to consider it a constant daily increase in the semi-major axis; this action must have reached its climax in the days near the time of perihelion. Now the basis elements of the 1910 return osculate 193 days before the perihelion date. Then the radius vector was 3.1 unit or 5.3 times the perihelion distance of the comet orbit. Therefore a Solar effect on the comet was reduced to 1:28. We may take it that a Solar effect on the comet has insignificant influence before that day, and that the integrated motion back to 1835 is almost in accordance with the law of gravitation. At the perihelion in 1835, of course, the Sun will also push the comet and give the non-gravitational delay of $4^{d}.30$ in 1759. It is important to keep in mind that by the backwards integration the effect acts with opposite sign.

During the perihelion passage in 1910 comet Halley gets a similar push by the Solar effect which will increase the period and delay the time of perihelion at the next return in 1986. This effect I have tried to take into account in the following way. At J.D. 2418980.5, which is 199 days after T in 1910, the radius vector reaches 3.2 and presumably the Solar effect again has terminated. On this day the osculating elements Va and Vb shown in Table 6 have been derived from the integrated coordinates and velocities. By means of the residuals from Table 8 and the correction d period $= 4^{d} \longrightarrow da = 0.001721500$ the equations of condition for the 1910 return have been solved again. The resulting corrections lead to the elements VIa and VIb. These elements, too, are shown in Table 6, and they are used as basis for a further integration forwards to 1986.

On the days around the expected day of perihelion in 1986 the elements are derived from the integrations of all 4 orbits. They are arranged in Table 10, where 4 columns give the different systems of osculating elements. The differences VIa minus Va are given as the variation corresponding to the resulting $3^{d}.9585$

delay in arriving to the perihelion in 1986. The differences of the variations in e and a show how sensitive the perturbation on these elements are. In Table 11 is given the predicted ephemeris for the coming return computed from the integrated coordinates of orbit Va, while the orbit VIa has been used to compute the variation in the positions due to $3^{d}.95852$ delay in the period. Also the star aberration is given in the ephemeris; it must be added to the geocentric observation before this is compared with the epehemeris position interpolated to $t - 0.00577\,\varrho$.

By means of the variation given in Tables 10 and 11 we can correct the elements and the ephemeris as soon as the comet has been observed.

$$\text{Delay} = 3.95852 \cdot \text{residual} : \text{variation}$$
$$\text{Correction} = \text{variation} \cdot \text{delay} : 3.95852$$

The existence of perturbations not originating in a radial pressure from the Sun can be proved if the corrected elements can not reproduce the new observations.

No attempt has been made to compute the residuals between the integrated orbits and the observations of 1759. But there is an easier way to show the missing perturbations in the integrated orbits.

The elements derived by Rosenberger from the 1759 observations, when reduced to the equinox 1950.0 and supplied with perturbations from 2363592.5 to 2363680.5 are compared with the integrated elements Vb Table 9 column 2, which originate in the 1910 apparition. The differences show the missing perturbations especially in Ω and i.

	Rosenberger 1759	Vb 1759	Correction to Integration
Epoch	2363680.5	2363680.5	
T	2363592.55055	2363588.24892	$4^{d}.30163$
ω	$110^{\circ}.7390$	$110^{\circ}.6878$	$0^{\circ}.0512$
Ω	56.5739	56.5280	0.0459
i	162.3980	162.3705	0.0275
q	0.5845238	0.5844825	0.0000413
e	0.9676585	0.9676633	−0.0000048

IV. Periodic Comet Olbers

In my previous investigation the elements for the 1887 return were in accordance with the time of perihelion in 1815, 1887 and 1956 provided the mass of Jupiter, used in the integration, gets the correction −0.34 per cent. But the residuals were not confirmed by means of continuous integration. The elements for 1956 were corrected assuming that the variation of the integrated period and the osculating semi-major axis in 1956 are both linear functions of the correction to the Jupiter mass. But only the first conclusion is true, therefore the elements for 1956 need a further correction based on the unchanged value for the mass of Jupiter. This correction has been made by means of least squares improvement with the residuals from the 1956 apparition combined with runs of integration from 1956 to 1887. The resulting elements of the final improvement are shown in Table 13 which also includes the integration back to 1815 and forwards to the next return in 2024.

In Table 14 are shown the normal places for all three apparitions and the perturbations from the epoch of osculation for the elements together with the residuals of the comparison with the normal places. These residuals are quite satisfactory in 1956 but a bit systematic in 1887 corresponding to a variation of p.004 in the denominator of the reciprocal mass of Jupiter used in the integration, which is due to the close approach of the comet to this planet in 1889.

For 1815 the time of perihelion has been corrected by 5ᵈ.49562 in the comparison with the normal places.

The predicted ephemeris for the next return in 2023–2024 is given in Table 15 together with the variation in the positions corresponding to an arrival 5 days later.

As in the case of comet Halley we can deduce the remaining perturbation by comparing the integrated elements 1815 VIIa in Table 13 with the elements computed by Ginzel[12] from the 1815 observations, when these last elements are integrated forwards to the same epoch as VIIa.

	Ginzel 1815	VIIa 1815	Correction to Integration
Epoch	2384250.5	2384250.5	
T	2384089.98880	2384084.48910	5ᵈ.49970
ω	65°.57832	65°.57331	0°.00501
Ω	85.34303	85.33798	0.00505
i	44.49993	44.49916	0.00077
q	1.2127846	1.2128258	−0.0000412
e	0.9310991	0.9316803	−0.0005812

V. Conclusion

The comparison of elements integrated from the basis apparitions with elements for the apparitions 1759 and 1815 discloses perturbations not originating in a Solar effect, because this can not alter the elements Ω and i. Most likely these unidentified perturbations originate in attractions from unknown masses far from the Sun or in pressure produced by streams of captured interstellar dust near the Sun. In the last case no constant effect in Ω and i could be expected.

An investigation by Yeomans(14), which includes a non-gravitational term in the direction of the radius vector of comet Halley represents the perihelion date back to the apparition in 1607, and also shows that no transverse non-gravitational reduction is required, unless the 1909–1911 observations are included in the solution, and prior to the 1910 return there does not appear to be a time dependence in the transverse non-gravitational accelerations for nearly a millennium.

The computers who in the future adjust the elements of these comets by means of the coming observations, will find out whether a similar discrepancy will appear between their improved elements and the elements predicted in this paper.

In this connection it is emphasized that after the 1986 apparition of comet Halley the comet will have been very well observed during three consecutive apparitions.

VI. Acknowledgement

The many runs of numerical integration have been done electronically at the Aarhus University by Mr. Ole Møller, mag. scient. by use of his own programme, and he has kindly helped by doing several control computations of different reductions. I am deeply indebted to Mr. Møller, for without his careful help, I would not have been able to carry out the investigation at all.

I also thank the authorities of the Aarhus University for having placed at my disposal the electronic computers belonging to the institution.

References on the last page.

Table 1.

	Jul. Ephem. Day 2410000 +	Comet Halley: Normal Places 1909–1911 α 1950.0	δ 1950.0	ϱ	Solar Coordinates X	Y	Z
1	8568.000107	95°20'36.84	17° 7'41"44	3.366	1.0013710	0.0724983	0.0314418
2	8596.000108	93 16 36.28	31 16 40.27	2.536	0.9169238	-0.3580033	-0.1553089
3	8628.000109	79 42 45.30	16 40 34.41	1.704	0.5657185	-0.7435594	-0.3225623
4	8648.000110	61 18 4.43	15 25 25.78	1.405	0.2493935	-0.8741928	-0.3792215
5	8660.000110	48 4 28.72	13 48 12.81	1.355	0.0421861	-0.9016866	-0.3911535
6	8676.000111	32 29 46.62	11 16 28.73	1.427	0.2352531	-0.8758700	-0.3799465
7	8688.000112	23 56 44.33	9 45 39.17	1.542	0.4323787	-0.8106762	-0.3516687
8	8704.000112	16 20 34.19	8 34 18.66	1.712	0.6637094	-0.6683246	-0.2899086
9	8712.000113	13 42 30.73	8 16 53.75	1.787	0.7608592	-0.5765350	-0.2500957
10	8720.000113	11 35 20.77	8 8 31.31	1.846	0.8429829	-0.4733570	-0.2053339
11	8732.000114	9 0 5.18	8 7 23.19	1.895	0.9348099	-0.3020114	-0.1310029
12	8740.000114	7 27 43.50	8 10 54.10	1.894	0.9736083	-0.1799297	-0.0780481
13	8780.000115	358 47 0.53	8 1 5.99	1.264	0.8857137	0.4344799	0.1884846
14	8788.000115	358 5 51.50	8 4 21.44	0.984	0.8150226	0.5418352	0.2350511
15	8796.000117	0 0 21.37	8 49 56.55	0.675	0.7292565	0.6392035	0.2772852
16	8804.000117	9 57 49.78	11 53 52.89	0.363	0.6299710	0.7248116	0.3144256
17	8815.000117	116 28 59.64	12 36 40.04	0.194	0.4750438	0.8204694	0.3559186
18	8818.000117	135 11 27.31	6 50 58.76	0.286	0.4297361	0.8417809	0.3651610
19	8822.000117	145 56 51.44	3 5 43.75	0.430	0.3676337	0.8668547	0.3760359
20	8826.000117	151 10 54.72	1 12 32.96	0.582	0.3038421	0.8880051	0.3852115

21	8831.000117	154	54	21.38	- 0	8	44.49	0.771	0.2221672	0.9087608	0.3942181
22	8840.000119	158	43	20.69	- 1	33	20.95	1.108	0.0716138	0.9298014	0.4033445
23	8848.000119	160	57	9.77	- 2	24	34.75	1.397	-0.0636193	0.9307304	0.4037418
24	8864.000119	164	22	36.36	- 3	48	42.77	1.941	-0.3283791	0.8826578	0.3828919
25	8888.000121	168	44	55.19	- 5	50	7.29	2.652	-0.6757444	0.6941598	0.3011195
26	8984.000125	181	24	23.02	-14	46	20.02	3.909	-0.6909160	-0.6511153	-0.2824575
27	9012.000128	181	36	34.21	-17	3	50.34	3.811	-0.2705334	-0.8690534	-0.3769947
28	9040.000128	178	29	0.55	-18	30	38.26	3.611	0.2139143	-0.8804776	-0.3819464
29	9068.000128	171	24	5.13	-18	14	30.70	3.450	0.6472706	-0.6815754	-0.2956603
30	9096.000128	161	52	2.96	-15	37	13.81	3.494	0.9271020	-0.3206944	-0.1391101
31	9124.000132	153	29	49.20	-11	32	22.30	3.834	0.9904010	0.1154625	0.0500922
32	9152.000132	148	41	33.48	- 7	49	57.12	4.421	0.8271983	0.5256160	0.2280126
33	9180.000132	147	20	43.64	- 5	27	5.22	5.129	0.4788910	0.8185809	0.3550959

The normal places in A.J. Vol. 71 p. 23 show the printing errors:
No. 9: for 13°20'20."21 read 13°11'20."21. No. 17 for 11°42'34."08 read 12°42'34."08

Table 2.

	Jul. Ephm. Day 2390000 +	Comet Halley: Normal Places 1835–1836 α 1950.0	δ 1950.0	ϱ	Solar Coordinates X	Y	Z
1	1514.310053	87°33'39."37	23°49'44."92	1.878	-0.8881820	0.4424851	0.1920154
2	1519.698829	88 43 4.53	24 28 12.97	1.696	-0.9271459	0.3662686	0.1589349
3	1525.297568	89 58 26.92	25 17 24.34	1.502	-0.9593915	0.2838830	0.1231752
4	1533.757370	92 5 32.80	27 1 18.12	1.199	-0.9916144	0.1548226	0.0671641
5	1539.622060	93 54 2.08	28 50 18.21	0.984	-1.0019341	0.0632780	0.0274370
6	1545.250472	96 15 12.32	31 30 44.20	0.775	-1.0023586	-0.0252302	-0.0109756
7	1548.827006	98 25 57.23	34 5 13.50	0.643	-0.9977623	-0.0813946	-0.0353504
8	1551.648106	100 56 16.80	36 58 18.96	0.539	-0.9914797	-0.1254775	-0.0544866
9	1553.411838	103 9 8.91	39 22 25.11	0.475	-0.9863705	-0.1528935	-0.0663857
10	1555.473105	106 53 50.80	43 3 17.84	0.401	-0.9792525	-0.1847402	-0.0802071
11	1557.427082	112 37 48.42	47 46 58.91	0.335	-0.9713744	-0.2147179	-0.0932167
12	1558.398526	116 57 24.40	50 42 26.60	0.304	-0.9670502	-0.2295335	-0.0996460
13	1559.448580	123 35 0.43	54 18 47.50	0.272	-0.9620729	-0.2454759	-0.1065643
14	1560.371394	132 5 42.77	57 43 32.27	0.247	-0.9574396	-0.2594209	-0.1126157
15	1561.436441	146 53 57.11	61 21 12.99	0.222	-0.9517920	-0.2754343	-0.1195646
16	1562.473270	167 54 7.94	63 5 8.71	0.202	-0.9459861	-0.2909354	-0.1262912
17	1564.343354	209 19 1.00	56 9 4.98	0.187	-0.9347509	-0.3186583	-0.1383213
18	1564.443778	211 4 45.37	55 25 10.97	0.187	-0.9341200	-0.3201381	-0.1389635
19	1564.514582	212 16 55.31	54 53 21.21	0.187	-0.9336735	-0.3211808	-0.1394160
20	1567.198866	239 39 53.36	32 16 2.43	0.216	-0.9157175	-0.3603474	-0.1564124

21	1572.904294	255	11	8.33	5	13	13.76	0.385	-0.8710198	-0.4409321	-0.1913857
22	1579.832918	259	45	54.96	- 5	54	1.05	0.639	-0.8052803	-0.5328950	-0.2312998
23	1588.164978	260	38	1.30	-11	36	43.73	0.946	-0.7109075	-0.6330807	-0.2747756
24	1671.418608	236	29	34.09	-29	46	54.67	1.574	0.6155771	-0.7053652	-0.3061087
25	1680.237729	231	0	36.29	-31	17	37.06	1.475	0.7286028	-0.6098164	-0.2646352
26	1686.547303	225	59	5.76	-32	12	43.44	1.407	0.7989580	-0.5323567	-0.2310199
27	1692.560907	220	11	58.31	-32	49	19.96	1.347	0.8569465	-0.4524127	-0.1963245
28	1701.213297	210	11	6.85	-32	54	28.97	1.282	0.9235376	-0.3288460	-0.1426906
29	1709.802007	198	51	5.79	-31	38	58.52	1.255	0.9688778	-0.1988580	-0.0862753
30	1719.813510	185	37	13.19	-28	19	44.95	1.285	0.9945594	-0.0419014	-0.0181602
31	1727.435225	176	47	43.80	-24	53	31.29	1.358	0.9940483	0.0787208	0.0341936
32	1729.364869	174	48	37.50	-23	58	1.16	1.382	0.9911753	0.1091162	0.0473860
33	1744.806535	162	47	43.09	-16	56	33.40	1.661	0.9294479	0.3451996	0.1498383
34	1765.596426	155	3	48.91	-10	21	0.40	2.188	0.7457046	0.6225451	0.2702038

A.N. 575 pag. 373: Westphalen's 4 normal places of 1835 Oct. 8 are united to No. 14

Table 3.
Comet Halley: Equations of Condition for Declination 1909–1911

	$\frac{d\alpha \cos\delta}{d\Omega}$	$\frac{d\alpha \cos\delta}{di}$	$\frac{d\alpha \cos\delta}{d\omega}$	$\frac{d\alpha \cos\delta}{de}$	$\frac{d\alpha \cos\delta}{dT}$	$\frac{d\alpha \cos\delta}{da}$		$d\alpha \cos\delta$	w
1	0.906	-0.230	-0.909	12.91	0.00050	-0.0253	=	-0.20	36
2	1.077	-0.277	-1.086	16.56	0.00074	-0.0321	=	-0.90	31
3	1.446	-0.294	-1.487	26.12	0.00278	-0.0495	=	0.64	31
4	1.595	-0.180	-1.671	33.32	0.00628	-0.0622	=	1.02	31
5	1.487	-0.059	-1.576	34.12	0.00851	-0.0631	=	-0.14	41
6	1.174	0.073	-1.257	30.17	0.01008	-0.0553	=	0.60	29
7	0.948	0.121	-1.015	26.07	0.01030	-0.0475	=	0.64	33
8	0.727	0.136	-0.781	21.65	0.01022	-0.0394	=	0.20	28
9	0.652	0.133	-0.699	20.04	0.01022	-0.0364	=	-0.59	20
10	0.594	0.127	-0.633	18.75	0.01032	-0.0341	=	-0.10	23
11	0.530	0.113	-0.558	17.35	0.01067	-0.0315	=	-0.15	18
12	0.492	0.103	-0.515	16.45	0.01116	-0.0299	=	-0.03	19
13	0.297	-0.007	-0.276	12.04	0.01389	-0.0219	=	-0.02	29
14	0.180	-0.068	-0.145	14.11	0.01218	-0.0257	=	-0.29	20
15	-0.092	-0.171	0.153	23.69	0.00787	-0.0433	=	0.96	24
16	-1.073	-0.346	1.200	60.95	-0.01001	-0.1113	=	0.25	12
17	-1.721	1.562	1.761	37.74	-0.10549	-0.0663	=	-2.22	14
18	-0.016	1.156	-0.010	-12.81	-0.04946	0.0252	=	1.55	19
19	0.578	0.794	-0.612	-25.23	-0.02098	0.0473	=	-0.33	13
20	0.721	0.604	-0.751	-25.94	-0.01083	0.0482	=	-0.30	29

21	0.761	0.472	-0.784	-24.29	-0.00508	0.0453	=	-0.98	36
22	0.755	0.348	-0.770	-21.22	-0.00109	0.0395	=	0.24	31
23	0.739	0.289	-0.749	-19.22	0.00029	0.0358	=	-0.10	10
24	0.712	0.222	-0.718	-16.64	0.00134	0.0311	=	0.44	14
25	0.694	0.172	-0.696	-14.53	0.00177	0.0272	=	0.31	9
26	0.786	0.118	-0.786	-13.03	0.00199	0.0246	=	-1.31	2
27	0.874	0.125	-0.871	-13.77	0.00201	0.0260	=	-0.19	2
28	1.014	0.145	-1.005	-14.86	0.00193	0.0282	=	1.40	12
29	1.165	0.175	-1.143	-15.71	0.00165	0.0302	=	0.64	5
30	1.244	0.198	-1.207	-15.30	0.00115	0.0302	=	1.81	9
31	1.198	0.198	-1.151	-13.54	0.00067	0.0271	=	3.35	4
32	1.089	0.180	-1.041	-11.58	0.00040	0.0235	=	2.52	3
33	0.988	0.158	-0.942	-10.11	0.00031	0.0207	=	-0.18	3

Table 3. (continued).
Comet Halley: Equations of Condition for Declination 1909–1911

	$\frac{d\delta}{d\Omega}$	$\frac{d\delta}{di}$	$\frac{d\delta}{d\omega}$	$\frac{d\delta}{de}$	$\frac{d\delta}{dT}$	$\frac{d\delta}{da}$		$d\delta$	w
1	-0.087	-0.789	0.289	-4.43	-0.00046	0.0085	=	0".51	33
2	-0.108	-0.980	0.332	-5.41	-0.00058	0.0103	=	0.88	75
3	-0.071	-1.349	0.328	-5.80	-0.00067	0.0110	=	-0.07	52
4	0.038	-1.536	0.205	-3.65	-0.00016	0.0070	=	-0.56	62
5	0.100	-1.514	0.107	-1.58	0.00055	0.0032	=	0.28	62
6	0.118	-1.318	0.024	0.35	0.00146	-0.0004	=	-0.20	57
7	0.101	-1.127	-0.006	1.01	0.00185	-0.0016	=	-0.16	38
8	0.072	-0.897	-0.031	1.46	0.00216	-0.0025	=	-0.42	48
9	0.060	-0.799	-0.042	1.64	0.00228	-0.0028	=	-0.75	38
10	0.049	-0.710	-0.052	1.81	0.00241	-0.0032	=	-1.31	18
11	0.033	-0.590	-0.067	2.09	0.00269	-0.0037	=	-1.67	31
12	0.023	-0.514	-0.076	2.24	0.00294	-0.0040	=	-1.44	29
13	-0.050	0.027	-0.112	2.01	0.00586	-0.0037	=	-1.42	62
14	-0.081	0.274	-0.107	1.88	0.00645	-0.0034	=	0.38	57
15	-0.145	0.719	-0.075	2.85	0.00678	-0.0053	=	-0.15	41
16	-0.343	1.864	0.058	7.33	0.00542	-0.0135	=	-0.54	20
17	0.891	4.757	-1.173	-32.51	0.04786	0.0584	=	0.18	24
18	0.376	3.110	-0.473	-11.29	0.02761	0.0198	=	-1.82	13
19	0.114	2.208	-0.112	- 1.63	0.01477	0.0024	=	0.66	22
20	0.034	1.733	-0.015	1.26	0.00916	-0.0027	=	0.19	48

21	-0.003	1.400	0.078	2.45	0.00549	-0.0048	=	0.20	44
22	-0.022	1.064	0.129	3.20	0.00298	-0.0062	=	-0.07	62
23	-0.026	0.904	0.147	3.33	0.00186	-0.0064	=	-0.34	14
24	-0.026	0.723	0.163	3.34	0.00081	-0.0064	=	-0.08	26
25	-0.021	0.594	0.173	3.24	0.00020	-0.0062	=	0.89	9
26	0.041	0.515	0.183	2.98	-0.00041	-0.0056	=	-2.39	6
27	0.067	0.542	0.196	3.13	-0.00051	-0.0059	=	0.06	5
28	0.077	0.594	0.229	3.61	-0.00062	-0.0067	=	-1.40	12
29	0.052	0.631	0.299	4.45	-0.00069	-0.0083	=	-1.79	21
30	0.001	0.653	0.375	5.12	-0.00061	-0.0098	=	-1.75	7
31	-0.028	0.582	0.399	4.95	-0.00040	-0.0097	=	-1.72	5
32	-0.027	0.512	0.371	4.23	-0.00020	-0.0085	=	-1.81	6
33	-0.018	0.448	0.332	3.54	-0.00010	-0.0073	=	-1.84	1

Table 4.
Comet Halley: Equations of Condition for Right Ascension 1835–1836

	$\frac{d\alpha \cos\delta}{d\Omega}$	$\frac{d\alpha \cos\delta}{di}$	$\frac{d\alpha \cos\delta}{d\omega}$	$\frac{d\alpha \cos\delta}{de}$	$\frac{d\alpha \cos\delta}{dT}$	$\frac{d\alpha \cos\delta}{da}$ T 1835	$\frac{d\alpha \cos\delta}{da}$ T 1910		$d\alpha \cos\delta$	w
1	0.700	-0.217	-0.729	16.37	0.0005	-0.0305	- 1.2	=	0".92	21
2	0.601	-0.235	-0.738	17.07	0.0002	-0.0318	- 0.4	=	1.36	23
3	0.715	-0.258	-0.751	18.06	-0.0003	-0.0336	0.6	=	2.08	23
4	0.732	-0.308	-0.774	19.70	-0.0016	-0.0337	3.7	=	1.67	18
5	0.743	-0.360	-0.793	21.31	-0.0033	-0.0397	7.5	=	2.19	28
6	0.744	-0.438	-0.805	23.18	-0.0063	-0.0432	14.4	=	1.56	28
7	0.730	-0.516	-0.801	24.44	-0.0097	-0.0456	22.0	=	2.32	23
8	0.678	-0.605	-0.760	24.69	-0.0144	-0.0462	32.6	=	1.79	23
9	0.614	-0.681	-0.702	24.16	-0.0188	-0.0453	40.6	=	-0.43	18
10	0.462	-0.802	-0.560	20.91	-0.0200	-0.0450	45.2	=	3.78	14
11	0.148	-0.964	-0.252	13.58	-0.0390	-0.0274	88.3	=	1.66	14
12	-0.078	-1.068	-0.028	8.28	-0.0472	-0.0182	106.9	=	4.99	5
13	-0.618	-1.192	0.525	- 6.93	-0.0619	0.0125	139.5	=	5.19	5
14	-1.284	-1.301	1.211	- 29.41	-0.0777	0.0508	176.1	=	9.34	24
15	-2.438	-1.318	2.420	- 66.52	-0.1116	0.1179	252.9	=	10.97	5
16	-3.815	-1.220	3.893	-121.45	-0.1155	0.2184	261.8	=	17.69	5
17	-4.647	-0.333	4.893	-170.08	-0.0890	0.3083	200.4	=	15.91	5
18	-4.607	-0.285	4.857	-169.69	-0.0855	0.3077	193.9	=	17.05	5
19	-4.576	-0.252	4.828	-169.28	-0.0835	0.3070	189.3	=	16.74	5
20	-2.729	0.391	2.973	-118.76	-0.0227	0.2124	51.7	=	9.14	9

21	-0.688	0.326	0.814	-	46.27	0.0095	0.0845	- 21.5	=	-0.48	14
22	-0.050	0.160	0.117	-	20.91	0.0142	0.0382	- 37.5	=	-0.10	32
23	0.196	0.056	-0.161	-	11.64	0.0130	0.0212	- 35.1	=	-1.68	18
24	0.710	-0.078	-0.767	-	22.12	0.0119	0.0399	- 26.9	=	1.36	1
25	0.844	-0.056	-0.908	-	25.10	0.0120	0.0453	- 27.1	=	4.79	1
26	0.969	-0.029	-1.036	-	27.64	0.0120	0.0500	- 27.1	=	7.84	2
27	1.093	0.009	-1.178	-	30.26	0.0118	0.0549	- 26.6	=	2.49	2
28	1.333	0.085	-1.338	-	33.78	0.0110	0.0616	- 24.9	=	2.16	9
29	1.531	0.176	-1.582	-	35.82	0.0095	0.0657	- 21.5	=	2.72	4
30	1.647	0.270	-1.676	-	35.11	0.0064	0.0650	- 15.9	=	0.31	14
31	1.627	0.314	-1.637	-	32.59	0.0052	0.0607	- 11.6	=	10.35	9
32	1.621	0.321	-1.627	-	31.79	0.0047	0.0593	- 10.6	=	1.75	3
33	1.430	0.326	-1.412	-	25.05	0.0022	0.0473	- 5.0	=	5.03	3
34	1.172	0.278	-1.143	-	18.46	0.0009	0.0353	- 2.1	=	15.07	1

Table 4.
Comet Halley: Equations of Condition for Declination 1835–1836

	$\frac{d\delta}{d\Omega}$	$\frac{d\delta}{di}$	$\frac{d\delta}{d\omega}$	$\frac{d\delta}{de}$	$\frac{d\delta}{dT}$	$\frac{d\delta}{da}$ T 1835	$\frac{d\delta}{da}$ T 1910		$d\delta$	w
1	-0.195	-0.847	0.266	- 6.60	-0.0018	0.0121	4.0	=	- 2″.78	21
2	-0.228	-0.895	0.292	- 7.48	-0.0021	0.0137	4.7	=	0.75	23
3	-0.272	-0.959	0.329	- 8.67	-0.0025	0.0159	5.7	=	- 0.95	23
4	-0.373	-1.094	0.412	- 11.45	-0.0036	0.0209	8.2	=	0.17	18
5	-0.488	-1.233	0.510	- 14.63	-0.0050	0.0269	11.4	=	0.60	28
6	-0.674	-1.425	0.672	- 20.24	-0.0074	0.0368	16.8	=	1.35	28
7	-0.870	-1.596	0.871	- 28.35	-0.0110	0.0516	25.0	=	0.90	23
8	-1.114	-1.764	1.073	- 33.93	-0.0135	0.0617	30.6	=	3.73	23
9	-1.330	-1.885	1.278	- 40.96	-0.0166	0.0745	44.3	=	1.80	18
10	-1.684	-2.031	1.619	- 52.81	-0.0214	0.0960	48.7	=	4.84	14
11	-2.163	-2.134	2.092	- 65.45	-0.0274	0.1265	62.1	=	6.27	14
12	-2.475	-2.168	2.407	- 79.18	-0.0306	0.1457	69.4	=	5.50	5
13	-2.794	-2.072	2.740	- 87.74	-0.0316	0.1709	72.0	=	7.70	5
14	-3.026	-1.907	2.992	-104.90	-0.0287	0.1911	65.2	=	6.98	24
15	-2.971	-1.545	2.964	-108.81	-0.0135	0.1988	30.8	=	7.70	5
16	-2.127	-1.092	2.115	- 86.91	0.0221	0.1598	- 50.0	=	0.18	5
17	0.800	-1.140	-1.023	12.22	0.0951	-0.0194	-222.4	=	-10.69	5
18	0.918	-1.187	-1.156	16.85	0.1001	-0.0276	-226.8	=	-11.56	5
19	0.995	-1.221	-1.245	19.81	0.1015	-0.0331	-229.9	=	-11.27	5
20	1.501	-2.295	-2.007	52.84	0.0885	-0.0976	-200.6	=	-11.62	9

21	0.172	-1.571	-0.577	13.23	0.0275	-0.0236	- 62.2	=	- 4.68	14
22	-0.112	-0.733	-0.169	1.37	0.0103	-0.0024	- 15.4	=	- 1.72	28
23	-0.124	-0.256	-0.081	- 1.21	0.0064	0.0022	- 12.2	=	- 1.39	18
24	0.285	0.869	-0.171	- 4.31	0.0005	0.0080	- 1.1	=	4.92	6
25	0.334	0.976	-0.180	- 4.04	-0.0001	0.0076	- 0.2	=	- 2.04	8
26	0.358	1.057	-0.170	- 3.41	-0.0007	0.0065	1.5	=	- 1.04	4
27	0.362	1.134	-0.140	- 2.29	-0.0013	0.0045	3.0	=	0.68	3
28	0.317	1.231	-0.044	0.42	-0.0024	-0.0003	5.4	=	5.02	4
29	0.210	1.292	0.112	4.08	-0.0033	-0.0070	7.4	=	- 3.68	4
30	0.051	1.295	0.311	7.95	-0.0035	-0.0142	7.9	=	- 2.94	15
31	-0.042	1.249	0.418	8.38	-0.0031	-0.0173	6.9	=	-12.68	9
32	-0.058	1.233	0.436	9.70	-0.0029	-0.0177	6.6	=	- 6.80	6
33	-0.106	1.065	0.469	9.01	-0.0016	-0.0167	3.6	=	- 2.83	1
34	-0.138	0.844	0.392	6.52	-0.0005	-0.0124	1.2	=	- 9.72	1

Table 5.
Comet Halley: Basis Elements

Elements		Preliminary *IV*	Improved *Va*	Improved *Vb*	Improved *Vc*
Observations		1910	1910–1835	1910	1835
Epoch		2418588.5	2418588.5	2418588.5	2391500.5
T (J.E.D.)		2418781.679713	2418781.679695	2418781.679726	2391598.938822
T (E.T.)		1910 4 20.179713	1910 4 20.179696	1910 4 20.179726	1835 11 16.438822
ω	Ecliptic 1950.0	111° 43′ 25″.120	111° 43′ 25″.386	111° 43′ 25″.213	110° 40′ 51″.946
Ω		57 50 43.903	57 50 44.869	57 50 44.075	56 48 3.133
i		162 12 53.108	162 12 52.744	162 12 53.126	162 15 20.794
ω	Equator 1950.0	188° 35′ 23″.470	188° 35′ 23″.038	188° 35′ 23″.478	188° 27′ 36″.983
Ω		131 36 58.218	131 36 57.389	131 36 58.302	131 31 44.379
i		159 45 47.556	159 45 47.186	159 45 47.509	160 4 59.425
q		0.58713829528	0.58714240530	0.58713893730	0.58659293060
e		0.96727918590	0.96727895732	0.96727915059	0.96741424985
a		17.9438779700	17.9438782258	17.9438782258	18.0015168550
n		46″.6801361445	46″.6801351462	46″.6801351462	46″.4561187966
Period		27763ᵈ.415170	27763ᵈ.415764	27763ᵈ.415764	27897ᵈ.293910

Px	0.5519170735	0.55191930163	0.55191739046	0.55223221660
Py	-0.8322970589	-0.83229571320	-0.83229684593	-0.83218250107
Pz	-0.0516638141	-0.05166169099	-0.05166385932	-0.05011849809
Qx	-0.7927887852	-0.79278652243	-0.79278854290	-0.79372758686
Qy	-0.5044876308	-0.50448981523	-0.50448786954	-0.50642086493
Qz	-0.3420207193	-0.34202274224	-0.34202092880	-0.33694869845
x	0.7583468030	0.75834712957	0.75834713832	0.95301407948
y	2.8753737992	2.87537003181	2.87537316472	1.51213998044
z	0.9130140045	0.91301577960	0.91301482991	0.62175081673
dx/dt	0.002686871124	0.0026868887679	0.0026868730491	0.0009220855059
dy/dt	-0.012686525728	-0.0126865303200	-0.0126865254493	-0.0167680480718
dz/dt	-0.002365624262	-0.0023656169012	-0.0023656270162	-0.0037779512674

Table 6.
Comet Halley

Elements Observations		Integrated *Va* 1910–1835	Integrated *Vb* 1910	Corrected *VIa* 1910–1835	Corrected *VIb* 1910
Osculation		2418980.5	2418980.5	2418980.5	2418980.5
T (J.E.D.)		2418781.690756	2418781.690537	2418781.690789	2318781.690570
T (E.T.)		1910 4 20.190756	1910 4 20.190537	1910 4 20.190789	1910 4 20.190570
ω	Ecliptic	111° 43′ 18″.726	111° 43′ 18″.552	111° 43′ 17″.766	111° 43′ 18″.303
Ω	1950.0	57 51 39.418	57 51 38.623	57 51 39.352	57 51 38.557
i		162 13 8.706	162 13 9.087	162 13 8.646	162 13 9.027
ω	Equator	188° 35′ 15″.863	188° 35′ 17″.302	188° 35′ 15″.507	188° 35′ 16″.946
Ω	1950.0	131 37 53.266	131 37 54.178	131 37 53.085	131 37 53.997
i		159 45 34.589	159 45 34.912	159 45 34.595	159 45 34,918
q		0.58698393730	0.58698047000	0.58698256970	0.58697910209
e		0.96736228924	0.96736248090	0.96736548904	0.96736568070
a		17.9848378942	17.9848372706	17.9865593942	17.9865587706
n		46″.5207580785	46″.5207604981	46″.5140794608	46″.5140818800
Period		27858^d.531407	27858^d.529958	27862^d.531410	27862^d.529961

Px	0.55217083702	0.55216892731	0.55217147390	0.55216956295
Py	-0.83212896251	-0.83213009519	-0.83212857681	-0.83212971031
Pz	-0.05166000859	-0.05166217565	-0.05165941370	-0.05166158084
Qx	-0.79261768354	-0.79261970389	-0.79261718082	-0.79261920184
Qy	-0.50471559572	-0.50471365194	-0.50471634345	-0.50471439847
Qz	-0.34208094828	-0.34207913493	-0.34208100982	-0.34207919665
x	-3.05045067345	-3.05045233942	-3.05045956967	-3.05046387414
y	0.53198107798	0.53199763824	0.53197638204	0.53199482496
z	-0.71039107602	-0.71038009769	-0.71039539777	-0.71038468711
dx/dt	-0.0105815098186	-0.0105814834441	-0.0105815772982	-0.0105815438913
dy/dt	0.0075311468662	0.0075311823625	0.0075311184444	0.0075311527318
dz/dt	-0.0010714364970	-0.0010713947194	-0.0010714660567	-0.0010714226440

Table 7.

	Perturbation at 1835 Return from 2391500.5 to Date of Normal Places					Perturbation at 1910 Return from 2418588.5 to Date of Normal Places				
	10^8	$10^8 \eta$	$10^8 \eta$	P.α	P.δ	$10^8 \zeta$	$10^8 \xi$	$10^8 \zeta$	P.α	P.δ
1	- 16	18	6	0″.01	0″.00	- 56	65	29	0″.07	0″.00
2	6	- 7	- 2	- 0.01	- 0.00	- 105	119	50	0.15	0.00
3	181	- 232	- 80	- 0.28	- 0.02	- 165	191	79	0.25	-0.01
4	419	- 551	- 195	- 0.96	- 0.16	- 281	321	130	0.52	-0.06
5	608	- 817	- 294	- 1.56	- 0.36	- 372	424	211	0.82	-0.07
6	911	- 1268	- 464	- 2.30	- 0.68	- 464	529	207	1.26	-0.33
7	1173	- 1680	- 624	- 2.73	- 0.91	- 531	594	230	1.70	-0.59
8	1566	- 2321	- 882	- 3.25	- 1.20	- 580	647	247	2.14	-0.96
9	1782	- 2668	- 1027	- 3.52	- 1.36	- 611	679	257	2.48	-1.34
10	2007	- 3023	- 1179	- 3.80	- 1.52	- 649	716	268	2.90	-2.06
11	2347	- 3546	- 1413	- 4.26	- 1.79	- 684	749	275	3.14	-3.21
12	2564	- 3857	- 1560	- 4.57	- 1.99	- 702	765	279	2.99	-4.05
13	5718	- 4198	- 840	- 6.72	- 2.67	- 722	779	281	2.13	-5.21
14	7837	- 5424	- 285	-10.93	- 2.95	- 738	792	282	0.26	-6.38
15	9774	- 7906	- 24	-24.45	- 4.66	- 757	821	282	- 6.32	-7.58
16	11036	- 11106	- 174	-74.53	-11.44	- 786	817	276	-14.27	-7.27
17	11536	- 15804	- 762	-35.74	36.90	- 804	844	270	-22.42	-0.98
18	11481	- 17092	- 976	29.31	10.38	- 806	845	269	-22.21	-0.62
19	11322	- 18777	- 1277	44.23	- 0.96	- 808	847	268	-22.06	-0.38
20	11074	- 20412	- 1588	44.50	- 4.17	- 837	879	241	-13.25	0.01

21	10657	- 23380	- 1986	44.52	- 5.44	- 919	977	147	- 6.12	1.13
22	9662	- 25716	- 2709	38.09	- 5.97	-1192	1449	64	- 4.65	0.20
23	8563	- 28479	- 3347	35.64	- 6.01	-1333	1195	-193	- 3.36	-0.83
24	5888	- 33545	- 4591	32.72	- 5.91	-2625	11463	646	- 8.29	-4.54
25	918	- 40387	- 6372	30.83	- 5.62	-2073	12385	940	-15.38	-4.92
26	-27621	- 67255	-12863	36.34	- 2.64	-1659	12994	1146	-17.72	-4.98
27	-37542	- 76493	-14666	42.70	- 1.29	-1241	13539	1344	-20.30	-4.74
28	-47666	- 86519	-16418	52.86	- 0.67	- 600	14271	1628	-24.22	-3.62
29	-57753	- 97282	-18134	65.98	- 2.33	82	14937	1908	-25.18	-1.56
30	-67579	-108658	-19809	76.18	- 6.43	940	15655	2279	-28.41	1.34
31	-76985	-120522	-21439	78.09	- 9.67	1637	16156	2494	-27.17	2.97
32	-85813	-132756	-23027	74.42	-10.37	1823	16282	2561	-26.75	3.28
33	-93905	-145172	-24538	69.85	- 9.80	3388	17201	3096	-22.63	4.35
34						5790	18298	3874	-18.24	4.01

Table 8.
Comet Halley: Final Residuals

	Va 1910		*Vb* 1910		*Va* 1835		*Vb* 1835		*Vc* 1835	
	$d\alpha \cos\delta$	$d\delta$	$d\alpha \cos\delta$	$d\delta$	$d\alpha \cos\delta$	$d\delta$	$d\alpha \cos\delta$	$d\delta$	$d\alpha \cos\delta$	$d\delta$
1	-0″.20	0″.34	-0″.18	0″.45	1″.20	-3″.37	1″.03	-3″.04	0″.82	-3″.25
2	-0.90	0.65	-0.88	0.80	1.64	0.04	1.45	0.43	1.29	0.20
3	0.85	-0.44	0.70	-0.16	2.32	-1.75	2.12	-1.30	1.96	-1.56
4	1.47	-0.96	1.11	-0.64	1.79	-0.96	1.56	-0.32	1.47	-0.67
5	0.47	-0.11	0.02	0.19	1.85	-0.79	1.97	-0.07	1.89	-0.51
6	1.25	-0.53	0.71	-0.27	1.28	-0.55	1.00	0.38	0.96	-0.24
7	1.29	-0.45	0.74	-0.22	1.71	-1.54	1.41	-0.37	1.39	-1.31
8	0.79	-0.66	0.29	-0.48	0.70	0.66	0.40	2.06	0.38	1.02
9	-0.01	-0.97	-0.50	-0.79	-2.05	-1.88	-2.31	-0.23	2.37	-1.49
10	0.46	-1.51	-0.03	-1.35	1.14	0.23	0.96	2.24	1.23	0.64
11	0.37	-1.86	-0.09	-1.70	-2.46	-0.16	2.28	3.16	-2.73	1.24
12	0.50	-1.60	0.02	-1.45	-0.31	-1.16	0.28	2.37	-0.32	0.05
13	0.45	-1.49	0.00	-1.41	-1.98	0.77	-1.38	3.83	-2.46	1.35
14	0.33	0.37	-0.24	0.40	-0.15	0.02	0.98	3.32	-0.76	0.36
15	2.18	0.04	1.11	-0.10	-0.54	2.23	1.65	5.60	-1.94	2.70
16	3.79	0.30	0.79	-0.39	1.19	-0.75	4.85	1.90	0.59	-0.15
17	0.85	-0.47	-1.45	-0.04	1.46	-0.77	5.66	-0.25	0.37	0.50
18	1.16	-1.47	1.64	-1.86	3.01	-1.50	7.19	-1.07	1.97	0.02
19	-1.71	1.40	-0.45	0.70	2.89	-1.03	7.07	-0.66	1.86	0.53
20	-1.81	0.99	-0.48	0.26	3.22	-2.18	4.70	-2.13	2.21	-0.36

21	-2.46	0.97	-1.18	0.26	-0.90	-2.46	0.29	-1.82	-1.35	-1.46
22	-1.11	0.65	0.06	-0.01	0.62	-1.15	1.25	-0.62	-0.24	-0.63
23	-1.36	0.36	-0.28	-0.27	-0.63	-1.20	-0.15	-0.85	-1.15	-0.86
24	-0.71	0.55	0.27	-0.03	1.04	5.08	2.39	4.95	-0.43	4.43
25	-0.73	1.48	0.15	0.94	4.26	-1.85	5.79	-2.06	2.50	-2.59
26	-2.35	-1.76	-1.47	-2.34	7.12	-0.81	8.82	-1.11	5.09	-1.59
27	-1.32	0.75	-0.36	0.12	1.55	0.98	3.41	0.56	-0.77	0.21
28	0.17	-0.62	1.22	-1.35	0.90	6.08	2.98	5.41	-1.81	5.44
29	-0.70	-0.87	0.45	-1.72	1.08	-3.02	3.36	-3.96	-2.04	-3.42
30	0.47	-0.74	1.61	-1.68	-1.52	-1.93	0.69	-3.17	-4.94	-1.99
31	2.13	-0.74	3.19	-1.67	8.48	-11.57	10.55	-12.87	5.20	-11.42
32	1.46	-0.90	2.37	-1.76	-0.63	-5.59	1.90	-6.98	-3.39	-5.43
33	-1.10	-1.04	-0.31	-1.79	3.38	-1.57	4.97	-2.86	0.54	-1.29
34					13.73	-8.63	14.95	-9.67	11.46	-8.42
ε	5".37		4".10		8".18		10".18		7".61	

Table 9.
Coment Halley: Integrated Elements, Coordinates, Velocities and Perturbations

Basis	*Va*	*Vb*	*Va*	*Vb*
Osculation	2363680.5	2363680.5	2391500.5	2391500.5
T (J.E.D.)	2363588.251964	2363588.248917	2391598.938921	2391598.938927
T (E.T.)	1759 3 8.751964	1759 3 8.748917	1835 11 16.438921	1835 11 16.438927
ω Ecliptic	110° 41′ 16″.508	110° 41′ 16″.138	110° 40′ 53″.396	110° 40′ 53″.173
Ω 1950.0	56 31 41.722	56 31 40.840	56 48 3.287	56 48 2.444
i	162 22 13.256	162 22 13.634	162 15 20.315	162 15 20.693
q	0.5844864725	0.5844825439	0.5865899834	0.5865865086
e	0.9676630898	0.9676632839	0.9674144119	0.9674146066
a	18.074901680	18.074888682	18.001515931	18.001516855
n	46″.173485487	46″.173535294	46″.456122257	46″.456118681
Period	28068ᵈ.056512	28068ᵈ.026235	27897ᵈ.291832	27897ᵈ.293980
Px	0.5488777146	0.5488762241	0.5522266539	0.5522247522
Py	-0.8342232729	-0.8342241299	-0.8321861823	-0.8321873152
Pz	-0.0529602235	-0.0529621723	-0.0501186659	-0.0501208090
Qx	-0.7968114374	-0.7968131537	-0.7937308231	-0.7937328333
Qy	-0.5030097058	-0.5030082313	-0.5064153594	-0.5064134341
Qz	-0.3347727126	-0.3347708431	-0.3369493498	-0.3369475072

x	-1.7047886078	-1.7048418891	0.9530188598	0.9530175653
y	-0.2770784638	-0.2770433340	1.5121343353	1.5121377682
z	-0.5243313767	-0.5243330316	0.6217509568	0.6217491305
dx/dt	-0.015737387976	-0.015737097276	0.000921995806	0.000921986016
dy/dt	0.007622852440	0.007622958884	-0.016768061997	-0.016768054467
dz/dt	-0.002395227770	-0.002395085389	-0.003777956236	-0.003777959548
Perturbation	1835 to 1759	1835 to 1759	1910 to 1835	1910 to 1835
In T	- 113^{d}.39513	- 113^{d}.39603	580^{d}.67438	580^{d}.67497
In ω	23$''$.112	22$''$.965	- 3751$''$.990	- 3752$''$.040
In Ω	- 981$''$.565	- 981$''$.604	- 3761$''$.582	- 3761$''$.631
In i	412$''$.941	412$''$.941	147$''$.571	147$''$.567
In e	0.0002486779	0.0002486773	0.0001354546	0.0001354560
In a	0.073385749	0.073371827	0.057637705	0.057638627

Table 10.
Comet Halley: Integrated Elements Near Perihelion 1986 at J. E. D. 2446400.0+*t*

t		*Va*	Variation	*VIa*	*Vb*	*VIb*
64.5	T=	66.963692	$3^{\mathrm{d}}.958522$	70.922214	66.963519	70.921812
66.5	T=	66.963687	3.958519	70.922206	66.963514	70.921804
68.5	T=	66.963183	3.958518	70.922201	66.963510	70.921800
70.5	T=	66.963680	3.958519	70.922199	66.963507	70.921797
72.5	T=	66.963677	3.958519	70.922196	66.963503	70.921794
64.5	ω=	$111^{\circ}.855507$	$-0^{\circ}.000281$	$111^{\circ}.855226$	$111^{\circ}.855459$	$111^{\circ}.855179$
66.5	ω=	111.855578	-0.000256	111.855322	111.855530	111.855275
68.5	ω=	111.855620	-0.000215	111.855405	111.855573	111.855358
70.5	ω=	111.855644	-0.000185	111.855459	111.855597	111.855412
72.5	ω=	111.855657	-0.000167	111.855490	111.855610	111.855443
64.5	Ω=	$58^{\circ}.152710$	$-0^{\circ}.000379$	$58^{\circ}.152331$	$58^{\circ}.152490$	$58^{\circ}.152111$
66.5	Ω=	58.152801	-0.000340	58.152461	58.152581	58.152241
68.5	Ω=	58.152857	-0.000292	58.152565	58.152637	58.152344
70.5	Ω=	58.152891	-0.000260	58.152631	58.152671	58.152411
72.5	Ω=	58.152912	-0.000241	58.152671	58.152692	58.152451
64.5	i=	$162^{\circ}.238504$	$-0^{\circ}.000065$	$162^{\circ}.238439$	$162^{\circ}.238609$	$162^{\circ}.238544$
66.5	i=	162.238495	-0.000060	162.238435	162.238600	162.238541
68.5	i=	162.238488	-0.000059	162.238429	162.238593	162.238534
70.5	i=	162.238481	-0.000058	162.238423	162.238587	162.238528
72.5	i=	162.238477	-0.000060	162.238417	162.238583	162.238523

64.5	e=	0.9672795251	0.0000022460	0.9672817711	0.9672797171	0.9672819633
65.5	e=	0.9672789890	0.0000028105	0.9672817995	0.9672791810	0.9672819916
66.5	e=	0.9672783710	0.0000032024	0.9672815734	0.9672785630	0.9672817654
67.5	e=	0.9672777403	0.0000033986	0.9672811389	0.9672779323	0.9672813309
68.5	e=	0.9672771371	0.0000034438	0.9672805809	0.9672773291	0.9672807729
69.5	e=	0.9672765793	0.0000034002	0.9672799795	0.9672767713	0.9672801715
70.5	e=	0.9672760716	0.0000033161	0.9672793877	0.9672762637	0.9672795796
71.5	e=	0.9672756128	0.0000032197	0.9672788325	0.9672758049	0.9672790245
72.5	e=	0.9672751990	0.0000031250	0.9672783240	0.9672753911	0.9672785160
64.5	a=	17.943116098	0.001505260	17.944621358	17.943115725	17.944621082
65.5	a=	17.942822288	0.001815394	17.944637682	17.942821904	17.944637366
66.5	a=	17.942483472	0.002030732	17.944514204	17.942483081	17.944513849
67.5	a=	17.942137629	0.002138596	17.944276225	17.942137238	17.944275841
68.5	a=	17.941806851	0.002163577	17.943970428	17.941806460	17.943970029
69.5	a=	17.941500942	0.002139749	17.943640691	17.941500555	17.943640287
70.5	a=	17.941222565	0.002093598	17.943316163	17.941222180	17.943315760
71.5	a=	17.940970949	0.002040777	17.943011726	17.940970567	17.943011326
72.5	a=	17.940744001	0.001988885	17.942732886	17.940743623	17.942732492

Table 11.
Comet Halley: Predicted Ephemeris

0^h E.T.			α 1950.0	Var. α	Aber.	δ 1950.0	Var. δ	Aberr.	ϱ	Var. ϱ
1981	Oct.	23	$7^h 17^m 36^s.23$	$3^s.99$	$0^s.26$	$8^\circ 43' \ 3''.9$	$-24''.4$	$4''.2$	12.807	0.021
		27	7 17 13.88	4.06	0.36	8 39 49.3	-24.2	4.0	12.720	0.021
		31	7 16 46.16	4.13	0.45	8 36 46.4	-24.0	3.7	12.634	0.021
	Nov.	4	7 16 13.09	4.21	0.54	8 33 56.6	-23.9	3.4	12.550	0.021
		8	7 15 34.71	4.30	0.63	8 31 21.2	-23.8	3.1	12.467	0.021
		12	7 14 51.10	4.40	0.72	8 29 1.1	-23.7	2.8	12.387	0.021
		16	7 14 2.36	4.51	0.81	8 26 57.6	-23.6	2.5	12.309	0.021
		20	7 13 8.62	4.63	0.88	8 25 11.7	-23.5	2.2	12.233	0.021
		24	7 12 10.02	4.76	0.96	8 23 44.3	-23.4	1.8	12.161	0.021
		28	7 11 6.77	4.89	1.03	8 22 36.4	-23.4	1.5	12.093	0.021
	Dec.	2	7 9 59.14	5.04	1.10	8 21 49.0	-23.4	1.1	12.028	0.021
		6	7 8 47.44	5.19	1.16	8 21 22.5	-23.4	0.7	11.966	0.021
		10	7 7 32.03	5.35	1.21	8 21 17.5	-23.4	0.3	11.910	0.021
		14	7 6 13.27	5.52	1.25	8 21 34.2	-23.4	0.0	11.857	0.021
		18	7 4 51.53	5.69	1.29	8 22 12.9	-23.5	-0.4	11.809	0.021
		22	7 3 27.23	5.85	1.32	8 23 13.7	-23.6	-0.8	11.767	0.021
		26	7 2 0.81	6.04	1.35	8 24 36.6	-23.7	-1.1	11.729	0.021
		30	7 0 32.80	6.21	1.36	8 26 21.5	-23.9	-1.5	11.696	0.021
1982	Jan.	3	6 59 3.70	6.38	1.37	8 28 27.8	-24.1	-1.9	11.668	0.021
		7	6 57 34.05	6.57	1.37	8 30 55.0	-24.3	-2.2	11.645	0.021
		11	6 56 4.36	6.74	1.36	8 33 42.4	-24.5	-2.5	11.628	0.021
		15	6 54 35.14	6.91	1.35	8 36 49.0	-24.8	-2.8	11.616	0.021
		19	6 53 6.87	7.08	1.32	8 40 13.9	-25.1	-3.1	11.609	0.021

	23	6 51 40.08	7.25	1.29	8 43 56.2	-25.4	-3.4	11.607	0.021
	27	6 50 15.29	7.39	1.25	8 47 54.8	-25.7	-3.6	11.610	0.021
	31	6 48 53.01	7.55	1.20	8 52 8.2	-26.1	-3.9	11.617	0.021
Oct.	22	7 10 28.18	5.36	0.28	9 28 26.3	-33.6	4.0	10.777	0.024
	26	7 10 0.20	5.47	0.37	9 24 49.6	-33.3	3.8	10.687	0.024
	30	7 9 25.76	5.59	0.46	9 21 25.2	-33.1	3.6	10.598	0.024
Nov.	3	7 8 44.85	5.72	0.56	9 18 14.7	-32.9	3.3	10.511	0.024
	7	7 7 57.47	5.87	0.65	9 15 19.3	-32.7	3.0	10.426	0.024
	11	7 7 3.65	6.04	0.74	9 12 40.5	-32.6	2.8	10.343	0.024
	15	7 6 3.46	6.22	0.82	9 10 19.6	-32.5	2.5	10.263	0.024
	19	7 4 57.04	6.43	0.90	9 8 18.2	-32.3	2.1	10.185	0.024
	23	7 3 44.62	6.64	0.98	9 6 37.2	-32.1	1.8	10.111	0.024
	27	7 2 26.48	6.87	1.05	9 5 18.0	-32.1	1.5	10.040	0.024
Dec.	1	7 1 2.93	7.12	1.11	9 4 21.2	-32.1	1.2	9.973	0.024
	5	6 59 34.30	7.37	1.17	9 3 47.7	-32.0	0.8	9.910	0.024
	9	6 58 0.99	7.65	1.22	9 3 38.0	-32.0	0.5	9.851	0.024
	13	6 56 23.41	7.93	1.27	9 3 52.9	-32.1	0.1	9.797	0.024
	17	6 54 42.08	8.22	1.31	9 4 32.7	-32.2	-0.2	9.748	0.024
	21	6 52 57.57	8.52	1.34	9 5 37.6	-32.4	-0.6	9.704	0.024
	25	6 51 10.49	8.82	1.36	9 7 7.6	-32.6	-0.9	9.664	0.024
	29	6 49 21.47	9.13	1.37	9 9 2.3	-32.8	-1.3	9.630	0.024
1883 Jan.	2	6 47 31.14	9.43	1.38	9 11 21.3	-33.0	-1.6	9.602	0.024
	6	6 45 40.11	9.74	1.37	9 14 4.0	-33.3	-2.0	9.578	0.024
	10	6 43 49.05	10.04	1.36	9 17 9.7	-33.6	-2.3	9.560	0.024
	14	6 41 58.64	10.34	1.34	9 20 37.7	-34.0	-2.5	9.548	0.024
	18	6 40 9.59	10.62	1.31	9 24 27.0	-34.4	-2.8	9.540	0.024

Table 11.
Comet Halley: Predicted Ephemeris

0^h E.T.			α 1950.0	Var. α	Aberr.	δ 1950.0	Var. δ	Aberr.	ρ	Var. ρ
1983	Jan.	22	$6^h 38^m 22^s.56$	$10^s.90$	$1^s.27$	$9^\circ 28' 36''.3$	$-34''.8$	$-3''.1$	9.538	0.024
		26	6 36 38.21	11.17	1.23	9 33 4.0	-35.2	-3.3	9.540	0.024
		30	6 34 57.11	11.44	1.18	9 37 48.8	-35.6	-3.5	9.547	0.024
	Feb.	3	6 33 19.80	11.70	1.12	9 42 49.0	-36.2	-3.7	9.559	0.024
		7	6 31 46.80	11.91	1.06	9 48 3.4	-36.6	-3.9	9.575	0.024
		11	6 30 18.60	12.08	0.99	9 53 30.1	-37.2	-4.0	9.596	0.024
		15	6 28 55.69	12.26	0.92	9 59 7.7	-37.7	-4.2	9.620	0.024
		19	6 27 38.46	12.44	0.83	10 04 54.2	-38.3	-4.3	9.647	0.024
	Nov.	22	6 51 07.22	10.71	1.02	10. 9 8.7	-50.5	1.8	7.738	0.029
		26	6 49 19.97	11.20	1.09	10 7 32.9	-50.4	1.5	7.665	0.029
		30	6 47 25.13	11.72	1.15	10 6 22.4	-50.3	1.2	7.596	0.029
	Dec.	4	6 45 23.17	12.28	1.21	10 5 38.6	-50.2	0.9	7.530	0.029
		8	6 43 14.65	12.86	1.25	10 5 22.3	-50.2	0.5	7.470	0.029
		12	6 41 0.25	13.47	1.30	10 5 34.4	-50.2	0.2	7.414	0.029
		16	6 38 40.72	14.10	1.33	10 6 15.3	-50.3	-0.1	7.364	0.029
		20	6 36 16.85	14.74	1.36	10 7 25.2	-50.4	-0.4	7.319	0.029
		24	6 33 49.45	15.39	1.37	10 9 3.9	-51.6	-0.7	7.279	0.029
		28	6 31 19.38	16.06	1.38	10 11 11.5	-50.8	-1.0	7.244	0.029
1984	Jan.	1	6 28 47.59	16.73	1.38	10 13 47.6	-51.2	-1.3	7.215	0.029
		5	6 26 15.08	17.39	1.37	10 16 51.9	-51.5	-1.5	7.192	0.029
		9	6 23 42.86	18.04	1.35	10 20 23.5	-51.9	-1.8	7.174	0.029
		13	6 21 11.98	18.68	1.32	10 24 21.4	-52.3	-2.0	7.162	0.029
		17	6 18 43.38	19.30	1.28	10 28 44.4	-52.8	-2.3	7.155	0.029

	21	6 16 18.00	19.89	1.24	10 33 30.8	-53.3	-2.5	7.155	0.028
	25	6 13 56.68	20.45	1.19	10 38 39.5	-53.9	-2.7	7.156	0.028
	29	6 11 40.30	20.98	1.13	10 44 8.9	-54.5	-3.0	7.164	0.028
Feb.	2	6 9 29.67	21.48	1.06	10 49 57.5	-55.2	-3.1	7.177	0.028
	6	6 7 25.56	21.93	0.99	10 56 3.6	-55.9	-3.3	7.193	0.028
	10	6 5 28.63	22.35	0.91	11 2 25.2	-56.6	-3.5	7.214	0.028
	14	6 3 39.41	22.73	0.82	11 9 0.4	-57.4	-3.6	7.238	0.028
	18	6 1 58.37	23.06	0.73	11 15 47.1	-58.3	-3.7	7.266	0.028
	22	6 0 25.86	23.34	0.64	11 22 43.7	-59.2	-3.8	7.296	0.028
	26	5 59 2.17	23.59	0.55	11 29 48.4	-60.1	-3.9	7.328	0.028
Mar.	1	5 57 47.60	23.79	0.45	11 36 59.4	-61.0	-4.0	7.363	0.028
	5	5 56 42.32	23.95	0.36	11 44 15.0	-62.0	-4.0	7.399	0.028
	9	5 55 46.43	24.07	0.27	11 51 33.2	-63.0	-4.0	7.437	0.028
	13	5 54 59.94	24.16	0.15	11 58 52.1	-64.1	-4.0	7.476	0.028
	17	5 54 22.76	24.20	0.06	12 6 10.1	-65.1	-4.0	7.515	0.028
	21	5 53 54.73	24.21	-0.03	12 13 25.3	-66.3	-4.0	7.554	0.028
Oct.	31	6 39 14.57	17.75	0.66	12 18 44.0	-110.4	2.7	5.277	0.036
Nov.	4	6 37 19.01	18.82	0.75	12 14 48.3	-110.2	2.6	5.182	0.036
	8	6 35 8.22	20.03	0.84	12 11 10.7	-109.9	2.4	5.090	0.036
	12	6 32 42.07	21.39	0.93	12 7 53.0	-109.6	2.2	5.001	0.036
	16	6 30 0.58	22.90	1.01	12 4 56.8	-109.2	2.0	4.916	0.036
	20	6 27 3.88	24.56	1.09	12 2 24.0	-108.7	1.8	4.834	0.036
	24	6 23 52.34	26.38	1.16	12 0 16.2	-108.3	1.6	4.757	0.036
	28	6 20 26.60	28.34	1.22	11 58 35.2	-107.7	1.4	4.685	0.036
Dec.	2	6 16 47.53	30.44	1.27	11 57 21.9	-107.0	1.1	4.618	0.036
	6	6 12 56.19	32.66	1.32	11 56 37.4	-106.3	0.9	4.556	0.036

Table 11.
Comet Halley: Predicted Ephemeris

0^h E.T.		α 1950.0	Var. α	Aberr.	δ 1950.0	Var. δ	Aberr.		Var. ϱ
1984 Dec.	10	$6^h\ 8^m 53^s.81$	$35^s.00$	$1^s.35$	$11^\circ 56' 22''.5$	$-105''.4$	$0''.7$	4.500	0.036
	14	6 4 41.80	37.43	1.37	11 56 37.5	-104.5	0.5	4.449	0.036
	18	6 0 21.74	39.95	1.39	11 57 22.9	-103.4	0.3	4.405	0.036
	22	5 55 55.48	42.50	1.39	11 58 39.4	-102.2	0.1	4.366	0.036
	26	5 51 25.06	45.07	1.39	12 0 27.2	-101.0	-0.1	4.334	0.036
	30	5 46 52.63	47.63	1.36	12 2 46.5	- 99.6	-0.3	4.309	0.036
1985 Jan.	3	5 42 20.34	50.16	1.34	12 5 37.0	- 98.2	-0.5	4.289	0.036
	7	5 37 50.31	52.62	1.30	12 8 58.4	- 96.8	-0.7	4.275	0.036
	11	5 33 24.58	54.99	1.25	12 12 49.8	- 95.4	-0.9	4.268	0.036
	15	5 29 5.12	57.24	1.19	12 17 11.3	- 94.0	-1.1	4.265	0.035
	19	5 24 53.83	59.36	1.12	12 22 2.4	- 92.8	-1.3	4.269	0.035
	23	5 20 52.54	61.32	1.04	12 27 23.0	- 91.5	-1.5	4.277	0.035
	27	5 17 2.82	63.12	0.96	12 33 12.2	- 90.6	-1.7	4.289	0.035
	31	5 13 26.03	64.75	0.87	12 39 29.1	- 89.9	-1.9	4.306	0.035
Feb.	4	5 10 3.20	66.20	0.78	12 46 12.3	- 89.1	-2.1	4.327	0.035
	8	5 6 55.19	67.48	0.68	12 53 20.8	- 88.8	-2.2	4.351	0.035
	12	5 4 2.59	68.59	0.58	13 0 53.6	- 88.8	-2.4	4.377	0.035
	16	5 1 25.95	69.52	0.47	13 8 49.7	- 89.0	-2.5	4.406	0.035
	20	4 59 5.62	70.30	0.36	13 17 7.7	- 89.6	-2.7	4.437	0.035
	24	4 57 1.75	70.92	0.26	13 25 46.2	- 90.4	-2.8	4.469	0.035
	28	4 55 14.28	71.41	0.15	13 34 43.5	- 91.8	-3.0	4.503	0.035
Mar.	4	4 53 42.99	71.77	0.04	13 43 57.5	- 93.5	-3.1	4.536	0.035
	8	4 52 27.54	72.01	-0.06	13 53 26.5	- 95.4	-3.3	4.570	0.035

	12	4 51 27.54	72.14	-0.16	14 3 8.8	- 97.7	-2.3	4.603	0.035
	16	4 50 42.61	72.17	-0.26	14 13 3.0	-100.5	-3.4	4.636	0.036
	20	4 50 12.31	72.07	-0.36	14 23 7.3	-103.1	-3.4	4.667	0.036
	24	4 49 56.12	71.98	-0.46	14 33 20.0	-106.9	-3.5	4.697	0.036
	28	4 49 53.45	71.77	-0.54	14 43 39.1	-110.7	-3.5	4.725	0.036
Apr.	1	4 50 3.66	71.50	-0.63	14 54 2.3	-114.8	-3.5	4.751	0.036
	5	4 50 26.09	71.18	-0.71	15 4 28.0	-119.2	-3.5	4.775	0.036
	9	4 51 0.13	70.81	-0.80	15 14 54.8	-123.9	-3.5	4.796	0.037
	13	4 51 45.23	70.39	-0.87	15 25 21.2	-128.9	-3.5	4.814	0.037
	17	4 52 40.86	69.94	-0.94	15 35 45.6	-134.3	-3.4	4.829	0.037
	21	4 53 46.44	69.45	-1.00	15 46 6.5	-140.0	-3.3	4.841	0.037
Aug.	23	6 3 54.48	40.43	-0.75	19 21 44.2	-503.8	1.3	3.181	0.055
	25	6 4 52.61	39.70	-0.72	19 23 41.3	-515.7	1.3	3.124	0.055
	27	6 5 48.39	38.97	-0.68	19 25 39.6	-528.3	1.4	3.067	0.055
	29	6 6 41.64	38.24	-0.64	19 27 39.6	-541.2	1.4	3.009	0.056
	31	6 7 32.17	37.50	-0.60	19 29 42.0	-554.8	1.4	2.950	0.056
Sep.	2	6 8 19.77	36.78	-0.56	19 31 47.2	-569.0	1.4	2.891	0.056
	4	6 9 4.21	36.08	-0.52	19 33 56.0	-584.0	1.4	2.831	0.057
	6	6 9 45.22	35.39	-0.48	19 36 8.9	-599.6	1.4	2.770	0.057
	8	6 10 22.53	34.74	-0.44	19 38 26.6	-616.1	1.4	2.709	0.057
	10	6 10 55.82	34.11	-0.39	19 40 49.9	-633.4	1.4	2.648	0.058
	12	6 11 24.76	33.53	-0.35	19 43 19.7	-651.8	1.4	2.586	0.058
	14	6 11 48.95	32.99	-0.30	19 45 57.0	-671.2	1.4	2.523	0.058
	16	6 12 8.01	32.53	-0.26	19 48 42.5	-691.8	1.4	2.460	0.059
	18	6 12 21.46	32.17	-0.21	19 51 37.7	-713.7	1.3	2.397	0.059
	20	6 12 28.85	31.90	-0.16	19 54 43.4	-737.1	1.3	2.334	0.059

Table 11.
Comet Halley: Predicted Ephemeris

0^h E.T.	α 1950.0	Var. α	Aberr.	δ 1950.0	Var. δ	Aberr.	ϱ	Var. ϱ
1985 Sep. 22	$6^h 12^m 29^s.65$	$31^s.76$	$-0^s.11$	19° 58′ 1″.2	−762″.0	1″.3	2.270	0.060
24	6 12 23.29	31.77	-0.06	20 1 32.2	-788.7	1.2	2.206	0.060
26	6 12 9.13	31.97	-0.01	20 5 17.9	-817.3	1.2	2.141	0.060
28	6 11 46.45	32.42	0.04	20 9 19.8	-848.0	1.2	2.077	0.061
30	6 11 14.44	33.12	0.09	20 13 39.3	-881.2	1.1	2.012	0.061
Oct. 2	6 10 32.18	34.17	0.15	20 18 18.4	-917.0	1.1	1.947	0.061
4	6 9 38.60	35.63	0.20	20 23 18.5	-955.8	1.0	1.882	0.062
6	6 8 32.53	37.59	0.26	20 28 41.7	-997.8	1.0	1.817	0.062
8	6 7 12.60	40.14	0.32	20 34 29.7	-1043.5	0.9	1.753	0.063
10	6 5 37.28	43.45	0.37	20 40 44.6	-1093.2	0.9	1.688	0.063
12	6 3 44.77	47.63	0.43	20 47 28.0	-1147.4	0.9	1.623	0.064
14	6 1 33.09	52.92	0.49	20 54 42.0	-1206.7	0.8	1.559	0.064
16	5 58 59.89	59.54	0.56	21 2 28.1	-1271.5	0.8	1.495	0.064
18	5 56 2.57	67.79	0.62	21 10 47.7	-1342.2	0.8	1.431	0.064
20	5 52 38.06	78.05	0.68	21 19 41.2	-1419.3	0.8	1.368	0.065
22	5 48 42.88	90.77	0.75	21 29 8.6	-1503.1	0.8	1.305	0.065
24	5 44 12.93	106.51	0.81	21 39 7.9	-1593.8	0.9	1.244	0.066
26	5 39 3.46	125.99	0.88	21 49 35.6	-1691.6	0.9	1.183	0.066
28	5 33 8.96	150.07	0.95	22 0 24.7	-1795.2	1.0	1.123	0.066
30	5 26 23.03	179.79	1.02	22 11 24.3	-1903.5	1.1	1.064	0.066
Nov. 1	5 18 38.35	216.42	1.08	22 22 17.2	-2013.4	1.3	1.007	0.067
2	5 14 21.38	239.64	1.11	22 27 33.8	-2074.4	1.4	0.976	0.067
3	5 9 46.50	261.55	1.15	22 32 38.2	-2120.0	1.5	0.952	0.067

4	5 4 52.54	239.62	1.19	22 37 25.5	-2169.8	1.7	0.925	0.066
5	4 59 38.24	316.86	1.22	22 41 50.4	-2215.5	1.8	0.898	0.066
6	4 54 2.32	349.00	1.25	22 45 45.4	-2255.4	2.0	0.873	0.066
7	4 48 3.47	384.44	1.28	22 49 2.1	-2287.5	2.1	0.847	0.066
8	4 41 40.40	423.42	1.31	22 51 31.3	-2309.6	2.3	0.822	0.066
9	4 34 51.82	466.14	1.34	22 53 2.0	-2318.8	2.6	0.799	0.066
10	4 27 36.62	512.80	1.36	22 53 21.7	-2311.9	2.8	0.776	0.065
11	4 19 53.51	563.69	1.38	22 52 16.2	-2285.1	3.1	0.754	0.065
12	4 11 41.76	618.77	1.40	22 49 29.9	-2234.5	3.4	0.733	0.064
13	4 3 0.64	678.08	1.42	22 44 45.5	-2155.3	3.7	0.712	0.064
14	3 53 49.82	741.51	1.43	22 37 44.7	-2043.1	4.1	0.693	0.063
15	3 44 9.34	808.80	1.43	22 28 8.4	-1893.2	4.4	0.676	0.062
16	3 33 59.74	879.52	1.42	22 15 36.9	-1700.9	4.8	0.659	0.061
17	3 23 22.13	953.04	1.42	21 59 51.6	-1462.6	5.2	0.644	0.059
18	3 12 18.20	1028.57	1.41	21 40 34.9	-1175.4	5.5	0.630	0.058
19	3 0 50.39	1105.03	1.39	21 17 32.0	- 838.1	5.9	0.618	0.056
20	2 49 1.75	1181.28	1.36	20 50 32.0	- 451.1	6.2	0.608	0.055
21	2 36 55.96	1255.96	1.33	20 19 28.9	- 17.5	6.5	0.599	0.052
22	2 24 37.37	1327.66	1.28	19 44 22.9	457.7	6.8	0.592	0.050
23	2 12 10.66	1394.98	1.24	19 5 20.7	965.9	7.0	0.586	0.048
24	1 59 40.90	1456.61	1.18	18 22 36.3	1496.9	7.2	0.583	0.045
25	1 47 13.13	1511.39	1.12	17 36 29.9	2039.2	7.3	0.581	0.043
26	1 34 52.44	1558.39	1.05	16 47 28.5	2580.3	7.3	0.581	0.040
27	1 22 43.51	1597.03	0.98	15 56 2.9	3107.3	7.3	0.583	0.037
28	1 10 50.61	1627.00	0.91	15 2 47.8	3608.1	7.3	0.586	0.034
29	0 59 17.46	1648.35	0.83	14 8 18.5	4072.8	7.1	0.591	0.031

Table 11.
Comet Halley: Predicted Ephemeris.

0^h E.T.		α 1950.0	Var. α	Aberr.	δ 1950.0	Var. δ	Aberr.	ϱ	Var. ϱ
1985 Nov.	30	$0^h48^m7^s.08$	$1661^s.37$	$0^s.76$	$13°13'10''.3$	$4493''.0$	$6''.9$	0.598	0.028
Dec.	1	0 37 21.84	1666.60	0.68	12 17 56.7	4863.6	6.7	0.606	0.025
	2	0 27 3.44	1664.79	0.60	11 23 7.7	5181.4	6.4	0.616	0.022
	3	0 17 12.96	1656.74	0.53	10 29 9.9	5446.0	6.1	0.627	0.019
	4	0 7 50.90	1643.36	0.45	9 36 25.3	5658.9	5.8	0.639	0.016
	5	23 58 57.30	1625.55	0.38	8 45 11.5	5823.0	5.4	0.653	0.013
	6	23 50 31.78	1603.49	0.31	7 55 42.3	5942.6	5.0	0.668	0.010
	7	23 42 33.69	1580.01	0.24	7 8 6.9	6022.4	4.7	0.683	0.007
	8	23 35 2.08	1558.18	0.17	6 22 31.8	6067.7	4.3	0.699	0.006
	9	23 27 55.90	1526.22	0.11	5 38 59.9	6083.7	3.9	0.716	0.004
	10	23 21 13.90	1497.75	0.05	4 57 32.3	6075.2	3.6	0.734	0.002
	11	23 14 54.84	1468.88	-0.01	4 18 7.7	6046.4	3.2	0.752	-0.001
	12	23 8 57.39	1439.98	-0.07	3 40 43.4	6002.2	2.8	0.771	-0.004
	13	23 3 20.24	1411.36	-0.13	3 5 15.7	5945.7	2.4	0.791	-0.006
	14	23 58 2.11	1383.27	-0.18	2 31 40.0	5880.2	2.1	0.810	-0.007
	15	22 53 1.71	1355.91	-0.23	1 59 51.1	5808.3	1.8	0.830	-0.008
	16	22 48 17.85	1329.41	-0.28	1 29 43.4	5732.2	1.5	0.850	-0.010
	17	22 43 49.36	1303.87	-0.33	1 1 11.4	5653.9	1.1	0.871	-0.011
	18	22 39 35.15	1279.37	-0.38	0 34 9.4	5574.9	0.8	0.892	-0.012
	19	22 35 34.19	1255.97	-0.42	0 8 31.6	5496.5	0.5	0.913	-0.014
	20	22 31 45.50	1233.68	-0.46	-0 15 47.5	5419.6	0.3	0.934	-0.015
	21	22 28 8.16	1212.53	-0.50	-0 38 53.0	5345.0	0.0	0.955	-0.016
	22	22 24 41.33	1192.52	-0.54	-1 0 50.2	5273.3	-0.2	0.981	-0.017

	23	22	21	24.19	1173.61	-0.58	-1	21	43.9	5205.0	-0.5	0.997	-0.018
	25	22	15	16.13	1139.08	-0.65	- 2	0	39.1	5079.9	-1.0	1.040	-0.020
	27	22	9	38.61	1108.77	-0.72	- 2	36	12.6	4971.5	-1.4	1.081	-0.022
	29	22	4	26.96	1082.48	-0.78	- 3	8	54.7	4880.4	-1.9	1.123	-0.023
	31	21	59	37.14	1059.84	-0.84	- 3	39	12.3	4807.0	-2.3	1.163	-0.023
1986 Jan.	2	21	55	5.60	1040.79	-0.90	- 4	7	29.4	4751.3	-2.6	1.203	-0.024
	4	21	50	49.22	1024.89	-0.95	- 4	34	7.2	4712.8	-3.0	1.241	-0.024
	6	21	46	45.25	1012.09	-1.00	- 4	59	24.8	4691.3	-3.3	1.278	-0.024
	8	21	42	51.23	1002.15	-1.04	- 5	23	39.6	4686.4	-3.6	1.314	-0.024
	10	21	39	4.97	994.86	-1.08	- 5	47	7.5	4697.8	-3.9	1.348	-0.024
	12	21	35	24.49	990.07	-1.12	- 6	10	3.2	4725.1	-4.1	1.380	-0.023
	14	21	31	48.03	987.56	-1.16	- 6	32	40.4	4767.8	-4.4	1.410	-0.022
	16	21	28	14.03	987.17	-1.19	- 6	55	12.0	4825.8	-4.6	1.439	-0.021
	18	21	24	41.16	988.66	-1.22	- 7	17	49.6	4898.3	-4.8	1.464	-0.019
	20	21	21	8.28	991.81	-1.24	- 7	40	44.3	4985.0	-5.0	1.487	-0.017
	22	21	17	34.51	996.32	-1.26	- 8	4	5.9	5084.8	-5.2	1.508	-0.016
	24	21	13	59.19	1001.88	-1.28	- 8	28	3.2	5196.7	-5.3	1.525	-0.013
	26	21	10	21.91	1008.13	-1.30	- 8	52	43.9	5319.0	-5.4	1.539	-0.010
	28	21	6	42.55	1014.64	-1.32	- 9	18	14.1	5449.7	-5.5	1.550	-0.007
	30	21	3	1.26	1020.96	-1.32	- 9	44	38.7	5586.8	-5.6	1.557	-0.004
Feb.	1	20	59	18.41	1026.69	-1.32	-10	12	0.7	5727.2	-5.6	1.560	-0.000
	3	20	55	34.63	1031.38	-1.33	-10	40	22.0	5868.5	-5.7	1.559	0.004
	5	20	51	50.64	1034.75	-1.33	-11	9	42.7	6007.7	-5.7	1.554	0.009
	7	20	48	7.28	1036.60	-1.33	-11	40	2.5	6142.8	-5.7	1.545	0.013
	9	20	44	25.30	1036.91	-1.32	-12	11	20.6	6272.4	-5.6	1.532	0.017
	11	20	40	45.38	1035.84	-1.31	-12	43	36.0	6395.7	-5.6	1.515	0.022

Table 12.
Comet Halley: Basis Coordinates for Start of Integration

J.E.D. 2418588.5	x (S_1)	y (S_1)	z (S_1)
Venus	.372082739432OE+00	-.561567314092 7E+00	-.276464195533 8E+00
Earth + Moon	.961712170244 7E+00	.246767156742 6E+00	.107055500740 4E+00
Mars	.138040259105 2E+01	.241791085519 7E+00	.737366163185 6E-01
Jupiter	-.543433199546 4E+01	.204383476871 7E+00	.220688995413 2E+00
Saturn	.876795937886 9E+01	.311446397763 3E+01	.908885699198 6E+00
Uranus	.692108906997 7E+01	-.167788195175 0E+02	-.745006895780 7E+01
Neptune	-.923216522383 8E+01	.262886002605 7E+02	.110011559370 3E+02
Pluto	.296644972488 6E+01	.435062323982 4E+02	.128412261554 1E+02
Comet Halley Va	.758347070920 0E+00	.287537002906 0E+01	.913015784160 0E+00
Comet Halley Vb	.758347079660 0E+00	.287537316197 0E+01	.913014834470 0E+00
Reduct. S_0 to S_1	-.586600000000 0E-07	-.275000000000 0E-08	.456000000000 0E-08

J.E.D. 2418588.5	x (S_0)	y (S_0)	z (S_0)
Mercury	.351882100000 0E+00	.164925000000 0E-01	-.273786000000 0E-01
Venus	.372082798092 0E+00	-.561567311342 7E+00	-.276464200093 8E+00
Earth + Moon	.961712228904 7E+00	.246767159492 6E+00	.107055496180 4E+00
Mars	.138040264971 2E+01	.241791088269 7E+00	.737366117585 6E-01
Jupiter	-.543433193680 4E+01	.204383479621 7E+00	.220688990853 2E+00
Saturn	.876795943752 9E+01	.311446398038 3E+01	.908885694638 6E+00
Uranus	.692108912863 7E+01	-.167788195147 5E+02	-.745006896236 7E+01
Neptune	-.923216516517 7E+01	.262886002633 2E+02	.110011559324 7E+02
Pluto	.296644978354 6E+01	.435062324009 9E+02	.128412261508 5E+02
Comet Halley Va	.758347129570 0E+00	.287537003181 0E+01	.913015779600 0E+00
Comet Halley Vb	.758347138320 0E+00	.287537316472 0E+01	.913014829910 0E+00

J.E.D. 2418980.5	x (S_1)	y (S_1)	z (S_1)
Venus	-.6279916783481E+00	-.3386502288602E+00	-.1128455365510E+00
Earth + Moon	.7337482620950E+00	.6115560461179E+00	.2652942813447E+00
Mars	-.1498983843619E+01	-.5573847068530E+00	-.2153935320705E+00
Jupiter	-.4861866114242E+01	-.2295881286949E+01	-.8660702134156E+00
Saturn	.7657333358135E+01	.4887470769569E+01	.1689679116348E+01
Uranus	.8329200959851E+01	-.1629049662946E+02	-.7256003880795E+01
Neptune	-.1040146026495E+02	.2591015470812E+02	.1087552406722E+02
Pluto	.2088319642487E+01	.4330097430078E+02	.1304238809606E+02
Comet Halley Va	-.3050450609914E+01	.5319811085182E+00	-.7103910662029E+00
Comet Halley Vb	-.3050452275879E+01	.5319976687797E+00	-.7103800878715E+00
Comet Halley VIa	-.3050459506130E+01	.5319764125800E+00	-.7103953879600E+00
Comet Halley VIb	-.3050463810600E+01	.5319948555000E+00	-.7103846773000E+00
Reduct. S_0 to S_1	.6354000000000E-07	.3054000000000E-07	.9814000000000E-08

Final Coordinates

J.E.D. 2444240.5	x (S_0)	y (S_0)	z (S_0)
Comet Halley Va	-.4996041993945E+01	.1516167456123E+02	.2359277198460E+01
Comet Halley Vb	-.4996017063671E+01	.1516168218334E+02	.2359298416028E+01
Comet Halley VIa	-.5005461545914E+01	.1517690737548E+02	.2360420022175E+01
Comet Halley VIb	-.5005435999270E+01	.1517691415756E+02	.2360441220376E+01
Reduct. S_0 to S_1	.3307290000000E-07	.6299690000000E-07	.3034100000000E-07

Table 12.
Comet Halley: Basis Velocities for Start of Integrations.

J.E.D. 2418588.5	dx/dt (S_0)	dy/dt (S_0)	dz/dt (S_0)
Venus	.17243890889912E-01	.97650325297927E-02	.33084490202490E-02
Earth + Moon	-.49160431980310E-02	.15145926470611E-01	.65702300469479E-02
Mars	-.19449520198908E-02	.13574159277865E-01	.62829962002394E-02
Jupiter	-.46478939179872E-03	-.66117388731925E-02	-.28254235970246E-02
Saturn	-.22286598424743E-02	.47907784144339E-02	.20763828650621E-02
Uranus	.36471608612547E-02	.11182655251965E-02	.43844835110896E-03
Neptune	-.30052994778944E-02	-.90898496289562E-03	-.29681509529435E-03
Pluto	-.22400886041703E-02	-.49672623548539E-03	.52118209969540E-03
Comet Halley Va	.26868897265400E-02	-.12686534630700E-01	-.23656193079000E-02
Comet Halley Vb	.26868740077000E-02	-.12686529760000E-01	-.23656294229000E-02
Reduct. S_0 to S_1	.95860000000000E-09	-.43107000000000E-08	-.24067000000000E-08

J.E.D. 2418588.5	dx/dt (S_0)	dy/dt (S_0)	dx/dt (S_0)
Mercury	-.57515400000000E-02	.25864120000000E-01	.14440250000000E-01
Venus	.17243889931312E-01	.97650368404927E-02	.33084514269490E-02
Earth + Moon	-.49160441566310E-02	.15145930781311E-01	.65702324536479E-02
Mars	-.19449529784908E-02	.13574163588565E-01	.62829986069394E-02
Jupiter	-.46479035039872E-03	-.66117345624925E-02	-.28254211903246E-02
Saturn	-.22286608010743E-02	.47907827251339E-02	.20763852717621E-02
Uranus	.36471599026547E-02	.11182698358965E-02	.43845075780896E-03
Neptune	-.30053004364944E-02	-.90898065219562E-03	-.29681268859435E-03
Pluto	-.22400895627703E-02	-.49672192478539E-03	.52118450639540E-03
Comet Halley Va	.26868887679400E-02	-.12686530320000E-01	-.23656169012000E-02
Comet Halley Vb	.26868730491000E-02	-.12686525449300E-01	-.23656270162000E-02

J.E.D. 2418980.5	dx/dt (S_1)	dy/dt (S_1)	dz/dt (S_1)
Venus	-.98223830155442E-02	-.15908991893113E-01	-.77867842475649E-02
Earth + Moon	-.11850520872740E-01	.11627646964681E-01	.50438986855709E-02
Mars	.57241254296914E-02	-.10686066562883E-01	-.50593230880308E-02
Jupiter	.33155783725653E-02	-.58442615729121E-02	-.25886479008709E-02
Saturn	-.34180266707703E-02	.42093324393680E-02	.18874557074356E-02
Uranus	.35336484791820E-02	.13718640678921E-02	.55114572467727E-03
Neptune	-.29596789219142E-02	-.10212369338571E-02	-.34392680946788E-03
Pluto	-.22400148053003E-02	-.55024430495935E-03	.50521888527470E-03
Comet Halley Va	-.10581510960364E-01	.75311503375451E-02	-.10714345208538E-02
Comet Halley Vb	-.10581484585989E-01	.75311858337442E-02	-.10713927433074E-02
Comet Halley VIa	-.10581578440000E-01	.75311219156600E-02	-.10714640806300E-02
Comet Halley VIb	-.10581545033100E-01	.75311562031000E-02	-.10714206679000E-02
Reduct. S_0 to S_1	-.11418000000000E-08	.34713000000000E-08	.19761000000000E-08

Final Velocities

J.E.D. 2444240.5	dx/dt (S_0)	dy/dt (S_0)	dz/dt (S_0)
Comet Halley Va	.23871124047642E-02	.38026852618534E-02	-.27662379619593E-03
Comet Halley Vb	.23871036447878E-02	-.38026893320326E-02	-.27663309506129E-03
Comet Halley VIa	.23857225384082E-02	-.37985982811474E-02	-.27600003707802E-03
Comet Halley VIb	.23857138584609E-02	-.37986026010257E-02	-.27600936959510E-03
Reduct. S_0 to S_1	-.32976340000000E-08	.14420700000000E-08	.11109600000000E-08

Table 13.
Integrated Elements of Comet Olbers Based on Improved Elements 1955 (VII C)

Elements	1815 (VII a)	1887 (VII b)	1955 (VII C)	2023 (VII d)
Osculation	2384250.5	2410550.5	2435320.5	2460000.5
x	-0.793907136	-0.708888372	2.566460980	3.766649922
y	-2.404254313	0.270538186	2.966922831	3.271100821
z	-0.401071969	0.929620751	1.273466768	-2.437346339
dx/dt	0.00339630757	-0.008436445507	-0.007988662498	-0.006604721062
dy/dt	-0.01066512733	-0.020080955946	-0.002857598905	-0.001404039502
dz/dt	-0.00942952765	-0.001323531605	0.007348293310	0.006589805078
T (J.E.D.)	2384084.48910	2410553.47168	2435643.65225	2460487.28282
T (E.T.)	1815 4 20.98910	1887 10 8.97293	1956 6 19.15225	2024 6 25.78282
ω Ecliptic	65°573314	65°344061	64°627618	64°377599
Ω 1950.0	85.337983	85.366492	85.416008	85.235710
i	44.499160	44.569836	44.607568	44.619470
q	1.212825768	1.19911627	1.17866090	1.17503019
e	0.931680321	0.930979122	0.930255960	0.930227660
a	17.75221701	17.37323983	16.89980827	16.84091696
n	0°013177262957	0°01361077603	0°01418670192	0°01426118154
Px	-0.613658317	-0.611630368	-0.606958096	-0.603658298
Py	0.172643763	0.175691275	0.186569629	0.192280591
Pz	0.770465834	0.771388922	0.772524202	0.773708494

Qx	-0.367980569	-0.369634506	-0.376298791	-0.381629857
Qy	-0.925883210	-0.925526736	-0.923650841	-0.921760197
Qz	-0.085618820	-0.082283676	-0.072583361	-0.068678882

All figures in this table are in barycentre S_1 and $k(\sqrt{1 + m_1}) = 0.01720210038$ is used to derive the elements.

Table 14.

Comet Olbers:	Normal Places		Perturbation		Residuals		Weight
J. E. D.	α 1950.0	δ 1950.0	dα	dδ	dα cos δ	dδ	
2384049.96285	54°52′ 2″.1	37°50′16″.6	13″.6	3″.2	2″.8	12″.9	2
4063.96285	61 56 46.7	44 50 7.3	12.6	1.0	8.6	15.5	7
4073.96285	69 2 35.8	49 44 6.0	11.8	- 0.7	9.3	12.6	9
4085.96285	80 46 45.4	55 11 2.7	10.2	- 3.1	5.5	6.9	5
4098.96285	98 56 10.8	59 41 17.5	7.7	- 5.8	2.5	- 3.4	8
4109.96285	118 55 58.3	61 10 30.0	4.7	- 6.7	0.3	9.0	6
4122.96285	144 5 16.3	58 50 17.2	0.7	- 7.8	- 5.3	1.3	5
4134.96285	163 38 40.2	52 56 17.1	- 1.3	- 5.9	-12.7	5.6	5
4148.96285	180 21 2.7	43 23 33.5	- 2.7	- 3.3	- 1.9	8.8	3
4160.96285	190 49 6.0	34 31 55.9	- 2.8	- 2.0	- 2.6	10.6	6
4184.96285	206 1 52.7	18 22 20.1	- 1.6	- 0.4	8.4	-15.5	1
4210.96285	218 32 35.7	5 7 57.2	- 0.6	0.0	13.5	- 1.0	0
2410516.0	136 28 13.5	29 41 9.8	0.0	- 0.1	- 1.3	0.6	24
532.0	155 12 29.0	29 37 6.0	0.0	0.0	- 1.5	0.1	36
543.0	168 46 47.0	28 9 25.1	0.0	0.0	- 0.5	- 0.5	13
566.0	195 51 4.0	21 38 55.7	0.0	0.0	2.9	- 0.5	13
589.0	218 9 16.1	13 9 1.6	0.1	- 0.2	4.7	- 1.2	7
609.0	233 30 6.4	6 30 42.8	0.1	- 0.6	4.4	- 2.2	4
629.0	245 54 44.0	1 21 11.4	0.1	- 1.0	4.8	- 3.1	7
653.0	257 46 21.8	- 2 59 30.8	- 0.1	- 1.6	5.7	- 5.5	4
684.0	268 49 50.8	- 6 31 42.2	- 1.0	- 2.7	4.7	- 3.5	2
719.0	275 12 50.1	- 9 20 47.7	- 3.2	- 4.7	7.1	- 3.6	2
734.0	275 37 44.1	-10 37 20.9	- 4.6	- 5.7	3.7	- 5.6	1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0

2435423.82352	61	38	43.5	-19	54	46.1	- 2.0	- 0.8	3.5	- 0.2	4
487.00169	44	18	21.6	- 9	34	48.0	- 6.3	- 0.9	- 0.4	- 1.4	10
510.16260	43	31	19.8	- 1	40	23.9	- 7.7	- 0.3	0.3	0.1	24
542.84532	48	47	26.4	10	28	0.1	- 9.1	1.6	- 1.1	1.2	22
569.66930	58	18	48.8	20	56	57.2	- 9.3	4.9	1.8	- 1.8	6
583.96790	65	4	34.9	26	19	51.8	- 8.5	7.5	0.9	- 0.6	6
600.10550	75	24	18.3	32	43	7.0	- 5.3	11.4	- 2.2	0.1	4
612.68104	85	25	21.3	37	19	10.9	0.1	14.6	0.0	1.5	6
630.61402	103	48	4.5	42	36	57.7	15.1	17.4	0.4	- 0.8	4
653.11957	123	37	53.0	44	26	12.9	44.3	10.0	- 0.7	1.7	4
675.11800	163	42	24.8	38	26	7.1	59.1	11.7	- 0.3	- 3.7	4
700.58413	190	39	9.8	25	8	0.8	51.7	34.2	- 1.3	- 1.5	11
719.06780	205	6	47.8	15	7	3.9	42.9	41.0	1.7	1.5	4
728.54636	211	24	54.4	10	28	59.2	38.9	42.0	0.6	1.5	4

The values of the original weights for 1815 and 1887 have been reduced in order to obtain homogeneity between the old systems and the new one used for the 1956 apparition.

Table 15.
Predicted Ephemeris for Comet Olbers.

0^h E.T.	α 2000.0	δ 2000.0	ϱ	r	Var. α	Var. δ	Var. ϱ	Var. r
2023 Aug. 14	$4^h\ 16^m\ 20^s$	$-13^\circ\ 59'.8$	4.060	4.066	$-101^s.6$	$-23'.6$	0.078	0.046
24	4 21 46	-14 31.5	3.843	3.972	-110.9	- 24.8	0.079	0.047
Sep. 3	4 26 5	-15 12.1	3.626	3.877	-120.9	- 26.0	0.080	0.047
13	4 29 0	-16 0.7	3.413	3.782	-131.5	- 27.1	0.082	0.048
23	4 30 15	-16 55.8	3.205	3.685	-142.4	- 28.2	0.085	0.048
Oct. 3	4 29 34	-17 54.8	3.007	3.588	-153.1	- 29.0	0.088	0.048
13	4 26 39	-18 54.2	2.822	3.490	-162.8	- 29.6	0.092	0.049
23	4 21 19	-19 48.5	2.652	3.391	-170.5	- 30.0	0.096	0.049
Nov. 2	4 13 31	-20 31.1	2.503	3.292	-174.8	- 30.1	0.101	0.050
12	4 3 25	-20 54.3	2.376	3.191	-174.2	- 30.2	0.107	0.050
22	3 51 33	-20 50.0	2.274	3.090	-167.7	- 30.4	0.112	0.050
Dec. 2	3 38 43	-20 11.9	2.197	2.987	-155.6	- 31.0	0.118	0.051
12	3 25 58	-18 57.2	2.146	2.885	-138.9	- 32.5	0.122	0.051
22	3 14 21	-17 6.3	2.118	2.780	-120.0	- 34.9	0.126	0.052
2024 Jan. 1	3 4 47	-14 43.8	2.111	2.676	-101.3	- 38.1	0.129	0.052
11	2 57 50	-11 56.0	2.119	2.571	- 84.9	- 42.1	0.131	0.052
21	2 53 47	- 8 49.2	2.139	2.465	- 72.1	- 46.5	0.133	0.053
31	2 52 41	- 5 30.1	2.165	2.359	- 63.3	- 51.3	0.134	0.053
Feb. 10	2 54 26	- 2 2.2	2.193	2.253	- 58.7	- 56.2	0.135	0.053
20	2 58 52	1 31.2	2.220	2.147	- 58.4	- 61.3	0.135	0.053

Mar. 1	3 5 50	5 8.4	2.242	2.041	- 62.1	- 66.4	0.135	0.053
11	3 15 13	8 48.5	2.257	1.936	- 70.3	- 71.8	0.134	0.053
21	3 26 56	12 31.1	2.264	1.832	- 83.2	- 77.3	0.134	0.052
31	3 41 3	16 16.0	2.261	1.730	-102.0	- 83.0	0.133	0.051
Apr. 10	3 57 40	20 3.0	2.247	1.632	-127.8	- 88.9	0.132	0.049
20	4 17 4	23 51.3	2.224	1.538	-163.0	- 94.7	0.131	0.047
30	4 39 37	27 39.3	2.191	1.450	-210.2	-100.2	0.130	0.044
Maj 10	5 5 54	31 23.6	2.149	1.370	-273.9	-104.6	0.128	0.040
20	5 36 38	34 58.5	2.100	1.300	-358.4	-107.3	0.125	0.035
30	6 12 41	38 14.0	2.047	1.244	-467.9	-106.4	0.120	0.028
Jun. 9	6 54 45	40 55.4	1.993	1.203	-602.5	-100.0	0.115	0.020
19	7 42 59	42 42.6	1.942	1.180	-751.4	- 85.7	0.107	0.012
29	8 36 14	43 13.3	1.901	1.177	-887.4	- 62.1	0.095	0.001
Jul. 9	9 31 47	42 10.7	1.875	1.193	-972.6	- 30.5	0.081	-0.008
19	10 26 4	39 31.6	1.869	1.228	-980.9	4.4	0.063	-0.018
29	11 16 10	35 31.0	1.888	1.279	-919.0	36.1	0.042	-0.026
Aug. 8	12 0 39	30 34.5	1.935	1.345	-815.8	60.1	0.020	-0.033
18	12 39 33	25 11.3	2.009	1.422	-701.4	74.6	-0.003	-0.038
28	13 13 34	19 45.8	2.109	1.507	-594.1	80.8	-0.023	-0.042
Sep. 7	13 43 39	14 35.0	2.229	1.600	-501.1	80.2	-0.042	-0.046
17	14 10 37	9 48.7	2.365	1.697	-423.5	77.0	-0.058	-0.049
27	14 35 11	5 30.9	2.513	1.797	-359.7	71.4	-0.071	-0.050
Oct. 7	14 57 51	1 42.3	2.666	1.900	-307.4	65.0	-0.082	-0.051
17	15 19 2	-1 38.4	2.822	2.005	-264.4	58.8	-0.090	-0.052
27	15 38 58	-4 15.9	2.975	2.110	-228.8	53.0	-0.097	-0.053

References

1. F. W. Bessel. Abhandl. der Königl. Akademie der Wissens. Berlin 1812–1813 p. 119.
2. F. W. Ginzel. Veröff. Rechen-Inst. Berlin Nr. 3 1893.
3. H. Q. Rasmusen 1. Kgl. Danske Vidensk. Selsk. Mat.-Fys. Medd. 24 Nr. 18 1948 and
   2. Publ. og Mindre Medd. fra Københavns Observatorium Nr. 194 1967.
4. P. H. Cowell and A. C. D. Crommelin. Publ. der Astron. Gesells. XXIII. 1910.
5. P. E. Zadunaisky. The Astronom. Journal Vol. 71 Nr. 1 1966.
6. H. Westphalen. Astronom. Nachrichten No. 573, 574, 575. 1846.
7. P. Herget. Astronomical Papers Vol. XIV. 1953.
8. G. Stracke. Bahnbestimmung der Planeten und Kometen. p. 321. 1929.
9. J. Schubart and P. Stumpff. Veröff. Astron. Rechen-Inst. Heidelberg Nr. 18. 1966.
10. Duncombe, Tufekcioglu and Larson. United States Naval Observ. Circ. Nr. 106. 1965.
11. G. M. Clemence. Astronomical Papers Vol. XIII Part UV. 1953.
12. H. Q. Rasmusen and O. K. Hesselberg. Kgl. Danske Vidensk. Selsk. Mat.-Fys. Medd. 28-10 195
13. Rosenberger. Astronm. Nachr. XII. 190. 1835.
14. D. K. Yeomans. Astronomical Journal Vol. 82 Nr. 6. 1977.

Errata.

Page 22 column 2 line 7 for $188^{\circ}35'23''.038$ read $188^{\circ}35'22''.038$
column 4 line 13 for $46''.4561187966$ read $46''.456118681$
column 4 line 14 for $27897^{d}.293910$ read $27897^{d}.293980$
Page 28 column 9 line 9 for 2.37 read -2.37

Indleveret til Selskabet oktober 1978.
Færdig fra trykkeriet september 1979.