Acta Universitatis Carolinae. Mathematica et Physica

Zdeněk Sekanina
General catalogue of original and future comet orbits

Acta Universitatis Carolinae. Mathematica et Physica, Vol. 7 (1966), No. 2, 3--66

Persistent URL: `http://dml.cz/dmlcz/142191`

Terms of use:

© Univerzita Karlova v Praze, 1966

Institute of Mathematics of the Academy of Sciences of the Czech Republic provides access to digitized documents strictly for personal use. Each copy of any part of this document must contain these *Terms of use*.

This paper has been digitized, optimized for electronic delivery and stamped with digital signature within the project *DML-CZ: The Czech Digital Mathematics Library* `http://project.dml.cz`

General Catalogue of Original and Future Comet Orbits

ZDENĚK SEKANINA*)
Public Observatory, Prague

(Received January 21, 1966)

This paper presents a General Catalogue of Original and Future Comet Orbits, containing important data on original orbits of 81 comets and on future orbits of 70 comets. In addition, data on the definitive orbits, which the computations started from, are included. A detailed discussion of the accuracy reached and of the resulting average corrections for planetary perturbations after comparing direct computations with the theory is also presented. Distributions of comet energy-changes through planetary action are then analyzed and compared with results of theoretical considerations. Finally, the question of possible interstellar origin of some comets is studied.

1. Introduction

The aim of this paper is to present as complete survey of the results of calculations of the original and future comet orbits as possible.

The two classes of comet orbits may be defined as follows:

The original orbit of a comet is the orbit along which the comet was moving before penetrating the sphere of appreciable planetary perturbations.

The future orbit of a comet is the orbit along which the comet will move after leaving the sphere of appreciable planetary perturbations.

From this general definition it becomes clear that the original and future orbits may be considered only for long-period and non-period comets, which recede far enough from the Sun.

If the comet's original (or future) orbit is an ellipse, it may be defined as the orbit along which the comet was moving (or will move) near its foregoing (or next) aphelion.

If the comet's original (or future) orbit is a hyperbola, it may be defined as the orbit along which the comet was approaching (or will leave) the solar system at infinity, without taking account of stellar perturbations.

---

*) A collaborator of the Astronomical Institute of the Faculty of Mathematics and Physics of the Charles University, Prague.

The reciprocal semi-major axes, $\frac{1}{a}$, of original and future comet orbits are of primary importance for cosmogonical problems of both the cometary system and the whole solar system.

The sign of the reciprocal semi-major axis of the original orbit indicates whether the nearly-parabolic comet comes from remote regions of the solar system (positive), or from interstellar space (negative), that of the future orbit, whether it will stay a member of the solar system in the future (positive), or will leave it for interstellar space (negative). In this way, the gravitational interaction between the solar system and interstellar space becomes apparent.

To be able to investigate these problems, a representative observational material should be available, which is the direct impulsion for completing the General Catalogue of Original and Future Comet Orbits, presented in this paper.

The initial point for computing original and future orbits of any comet is its definitive orbit, i.e. its osculating elements referred to a date, usually close to the comet's perihelion passage. After applying planetary perturbations backward (or forward) during a long enough period, the original (or future) orbit is reached. This orbit, however, is all the time referred to the Sun as the centre of gravity, since the definitive orbit is computed in the heliocentric system of co-ordinates. As shown for the first time by STRÖMGREN (1898, 1899a, 1899b) the original and future orbits should be referred not to the Sun, but to the centre of gravity of the solar system, or to the barycentre, represented with a sufficient accuracy by that of the Sun and the nine major planets. The conversion into the barycentric system is according to STRÖMGREN necessary to ensure convergency of the perturbation function, since only then the oscillation term describing the gravitational influence of perturbing bodies on the Sun disappears. There is also another, fundamental reason for referring the orbit to the barycentre: original and future comet orbits are computed, since we are interested in motions of comets at large distances relative to the solar system, not to the Sun.

For the above-mentioned analysis of the data on original and future comet orbits, we need to know not only their values but also the errors involved. The resulting accuracy with which we obtain the values of reciprocal semi-major axis of original and future orbits depends (1) on the accuracy of the definitive orbit, (2) on the errors cumulated due to various omissions and simplifications in the computing method used for determining the original and future orbits from the definitive elements, and (3) on the accuracy kept in the course of direct calculations (interpolation, step of integration, rounding errors etc.).

The discussion of the errors of the first group belongs among the problems connected with the determination of the definitive orbit and it results in the mean error of the reciprocal semi-major axis,usually published by the author of the definitive orbit.

The errors of the second group were thoroughly discussed by BILO and VAN DE HULST (1960). I will often refer to their paper hereinafter. The formulae given by the Dutch astronomers are verified in detail in Sections 4 and 5 of the present paper.

The errors of the third group are probably irrelevant for the result, as mentioned by BILO and VAN DE HULST (ibid.). After all, we have hardly any possibility of their investigation theoretically.

2. Outline of History of the Work on Original and Future Orbits

The first original orbit derived was that of Comet 1886 II by THRAEN (1894). However, he omitted the reduction of the problem to the barycentric system. The first reliable original orbits were published by STRÖMGREN in 1914 in his famous paper „Über der Ursprung der Kometen". The paper contains important theoretical considerations and, in addition, original orbits for eight comets.

Meanwhile, FAYET (1910) developed a simplified method for computing original orbits, taking into account only Jupiter's perturbations and including a number of approximations, giving thus only rough resulting values. FAYET computed in this way original orbits for 146 comets. His results led to some interesting statistical conclusions, but they cannot be considered precise enough to be included in any list of reliable original orbits.

In the next years, much work was done by the Copenhagen astronomers, namely STRÖMGREN, RASMUSEN and SINDING. A few other original orbits were computed by BÜTTNER in 1918, MIKHAILOV in 1924, VAN BIESBROECK since 1927, GENNARO in 1937 etc.

In 1948 a list of 21 reliable original orbits was published by SINDING, which was in 1956 extended to a total of 26 comets by DIRIKIS. A few more complete lists have appeared recently.

Since 1958 GALIBINA has computed a few tens of original orbits, using MAKOVER'S modification of the computing method (MAKOVER 1955) with the true anomaly instead of time as integration variable.

Since 1960 Dutch astronomers, BILO, VAN HOUTEN-GROENEVELD and PELS-KLUYVER, have published other nearly 30 original orbits, and recently some Americans, in addition to VAN BIESBROECK, have started dealing with these computations, namely MARSDEN and BRADY, using modern digital computers. The author started with these computations in 1964 when a coded program for a Zuse Z23 computer was ready to be applied.

The history of the work on future comet orbits may be outlined in a similar way. The difference consists in the fact that the computations started much later. The present number of comets with the original orbit known is, however, only 16 per cent higher than that of comets with the future orbit known.

The first 36 future orbits were derived by FAYET (1933). He used an approximate method similar to his method for computing original orbits. Neither the original nor future values of semi-major axis of cometary orbits derived by FAYET are included in the present General Catalogue.

The first comparatively reliable future orbit was derived by VAN BIESBROECK in 1945 for Comet 1914 V. The realization of such computations was called for by CHANDRASEKHAR (1944), who was interested in this problem in connection with his theory of stability of binary systems and his estimation of the time of dissolution of a binary. A few other future orbits were determined by SINDING in the course of the forties and fifties. Much work on the future orbits has recently been done by GALIBINA, BRADY and some other astronomers.

A strong development of computing both original and future comet orbits in the recent years is well apparent from Figure 1. The number of comets of a known original or future orbit is plotted against time.

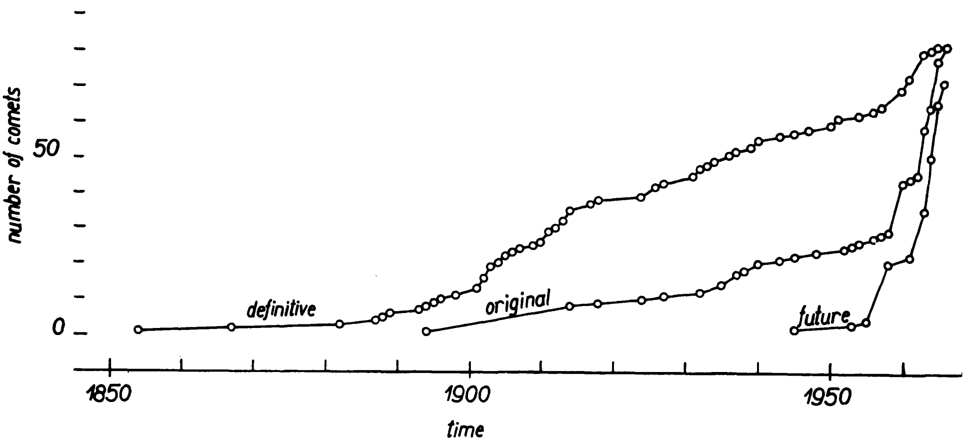


Fig. 1. *The growth in time of comets with known original and future orbits. The dates of determination of the corresponding definitive orbits are plotted for comparison.*

The common effort or astronomers all over the world has made it possible to complete the General Catalogue of Original and Future Comet Orbits, containing the data on 81 comets of the years 1844 to 1960.

3. Discussion of the Accuracy in the Original and Future Values of Semi-major Axis. The Theory

For having a possibility of both weighing several different values of unequal qualities given by various authors for the same original of future semi-major axis, and reducing the published values to a uniform system, a thorough discussion of the influence of an omission of both planetary perturbations and the reduction to the barycentre is necessary.

These problems were theoretically settled by Bilo and van de Hulst (1960). For a planet of mass m_i and time t, corresponding to heliocentric distance r, Bilo and van de Hulst gave the following formulae for the average values of the difference between the original and osculating (at time t) reciprocal semi-major axes:

(a) in the barycentric system

$$\Delta\left(\frac{1}{a_b}\right) = 2m_i \,.\, \left(\frac{1}{a_i} - \frac{1}{r}\right) \tag{1}$$

for $r < a_i$, and

$$\Delta\left(\frac{1}{a_b}\right) = 0 \tag{2}$$

for $r > a_i$,

(b) in the heliocentric system

$$\Delta\left(\frac{1}{a}\right) = \frac{2m_1}{a_1} \tag{3}$$

for $r < a_1$, and

$$\Delta\left(\frac{1}{a}\right) = \frac{2m_1}{r} \tag{4}$$

for $r > a_1$, where a_1 is the semi-major axis of the nearly circular orbit of the planet of mass m_1.

The average value of the reduction to the "barycentre", identical with the centre of gravity of the Sun and the planet of m_1 is according to the two Dutch astronomers

$$c = \frac{2m_1}{r} \tag{5}$$

for any r.

4. Discussion of the Accuracy in the Original and Future Values of Semi-major Axis. The Outer Planets

This section deals with the comparison of the theory with the computations made by Galibina (1958, 1963, 1964), Barteneva (1965) and Sekanina (1966) for original and future orbits of 54 comets. The outer planets are considered only.

The difference between the original (or future) and osculating reciprocal semi-major axes in the barycentric system was investigated for 8 heliocentric distances, and the result based on 107 individual values (54 future and 53 original) is included in Table 1.

Table 1

r	$\Delta\left(\frac{1}{a_b}\right)$ in 10^{-6} (a.u.)$^{-1}$					
	Theory					Direct computations
	S	U	N	P	Total	
100	0	0	0	0	0	0 ± 0
60	0	0	0	0	0	0 ± 0
30	0	0	−0.01	−0.04	−0.05	-0.2 ± 1.7
20	0	0	−1.7	−0.1	−1.8	-1.1 ± 4.8
15	0	−1.3	−3.5	−0.2	−5.0	-3.4 ± 11.3
12	0	−2.7	−5.2	−0.3	−8.2	-6.7 ± 19.5
10	0	−4.2	−6.9	−0.4	−11.5	-12.0 ± 31.9
8	−11.5	−6.4	−9.5	−0.6	−28.0	-26.7 ± 56.6

The individual columns give the heliocentric distance, the theoretical values of $\Delta\left(\frac{1}{a_b}\right)$ resulting from BILO'S and VAN DE HULST'S formulae for individual planets and the total, and the $\Delta\left(\frac{1}{a_b}\right)$ values with their root-mean-square deviations as result from the direct computations. The results of Table 1 lead to three important findings:

1. The average values of $\Delta\left(\frac{1}{a_b}\right)$ are in close agreement with those given by the theory.
2. The root-mean-square deviations are never smaller than both the differences between the theoretical and direct values, and the $\left(\frac{1}{a_b}\right)$ value itself.
3. There is a close relation between the $\Delta\left(\frac{1}{a_b}\right)$ values and their root-mean-square deviations. The relation is plotted in Figure 2 by open circles.

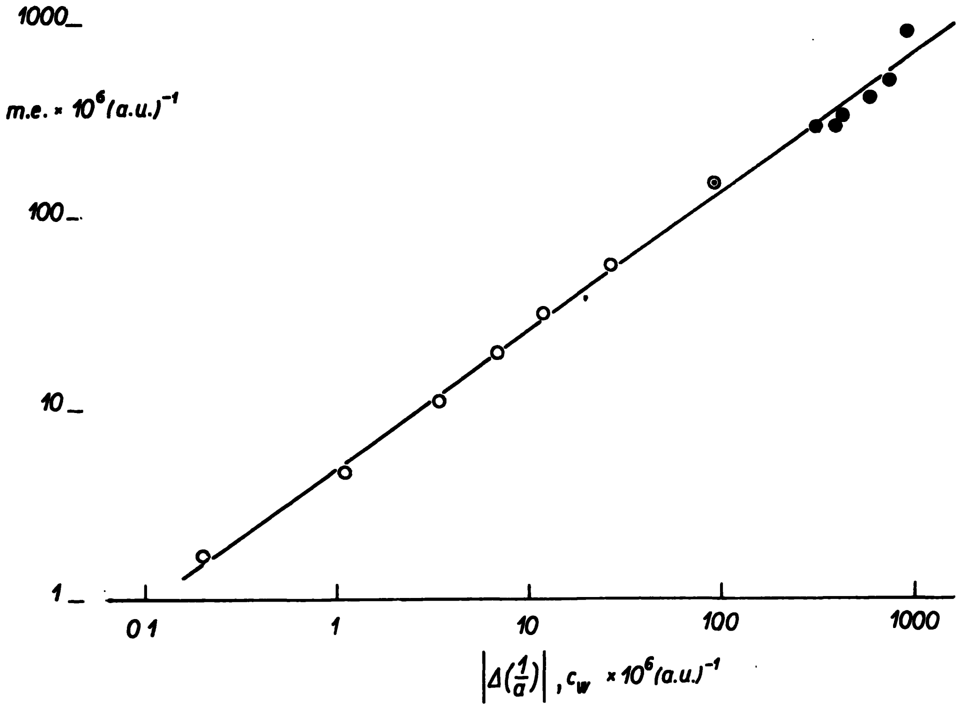


Fig. 2. *The relation between* $\left|\Delta\left(\frac{1}{a}\right)\right|$, *or* c_w *and its root-mean-square error.*

On the basis of the same material the dependence was studied, of the average value of the reduction to the barycentre, c_W, defined by both GALIBINA and BARTENEVA and SEKANINA as the centre of gravity of the Sun and the five outer planets. The results are included in Table 2, compared again with the theoretical data as follow from formula (5).

Table 2

int r	$\bar{r}$	c_W in 10^{-6} (a.u.)$^{-1}$							
		Theory						Direct computations	N
		J	S	U	N	P	Total		
2.5–3.5	3.35	570.0	170.5	26.1	30.9	1.7	799.2	900.4 ± 923.8	11
3.5–4.5	4.10	465.8	139.3	21.3	25.3	1.4	653.1	754.1 ± 515.4	57
4.5–5.5	4.99	382.7	114.5	17.5	20.8	1.1	536.6	602.6 ± 418.7	59
5.5–6.5	5.90	323.7	96.8	14.8	17.6	0.9	453.8	430.4 ± 348.7	39
6.5–7.5	6.93	275.6	82.4	12.6	14.9	0.8	386.3	401.0 ± 295.7	16
7.5–8.5	8.00	238.7	71.4	10.9	12.9	0.7	334.6	313.0 ± 297.3	9

The three authors convert the heliocentric problem into the barycentric problem generally close to the distance of Jupiter from the Sun, the minimum being about 3 a.u., the maximum more than 8 a.u.

BILO and VAN HOUTEN-GROENEVELD (1960), PELS-KLUYVER (1960) and VAN HOUTEN-GROENEVELD (1963b) convert it after finishing the integration of perturbations, at an average distance of 24 a.u. The results based on 26 individual data are in Table 3.

Table 3

int r	$\bar{r}$	c_W in 10^{-6} (a.u.)$^{-1}$						
		Theory						Direct computations
		J	S	U	N	P	Total	
19.7–27.6	24.0	79.6	23.8	3.6	4.3	0.2	111.5	92.4 ± 155.2

Tables 2 and 3 indicate a good agreement between the theory and direct computations. In Fig. 2 the data of Table 2 are given by full circles, that of Table 3 by a point bounded with an open circle. There is a well pronounced relation between the c_W-values and their root-mean-square deviations, very close to that between the $\Delta\left(\frac{1}{a_b}\right)$ values and their deviations. The two relations may be put together to form a general relation able to give the root-mean-square deviation for any value of $\Delta\left(\frac{1}{a_b}\right)$ or c_w, as just presented in Fig. 2. It may be written in the form:

$$R = 5.01\ M^{0.714}, \tag{6}$$

R is the root-mean-square deviation, M is either the absolute value of $\Delta\left(\frac{1}{a_b}\right)$ or c_w, all being expressed in 10^{-6} (a.u.)$^{-1}$.

5. Discussion of the Accuracy in the Original and Future Values of the Semi-major Axis. The Inner Planets

In this section BILO's and VAN DE HULST's theory is compared with direct computations made by BILO and VAN HOUTEN-GROENEVELD (1960), PELS-KLUYVER (1960) and VAN HOUTEN-GROENEVELD (1963b) for original and future orbits of 26 comets. The inner planets are considered here only. Due to both a small number of the comets available and a narrow range of heliocentric distances no dependence on the distance from the Sun is studied now.

In contradistinction to the outer planets, the total influence of the inner planets on the cometary motion will be here in its average values investigated, since it is just what may be best of all deduced from the data on 26 comets published by the three Dutch astronomers. Since the date of osculation of the definitive orbits is, as a rule, very close to the respective date of perihelion passage, the total omission of a planet of mass m_i yields an average difference in the semi-major axis:

$$\Delta\left(\frac{1}{a}\right)_q = \frac{2m_i}{a_i} \tag{7}$$

for $q < a_i$, and

$$\Delta\left(\frac{1}{a}\right)_q = \frac{2m_i}{q} \tag{8}$$

for $q > a_i$. These formulae are analogous to (3) and (4), respectively.

The comparison of the theory with direct computations is represented in Table 4. The theory is again consistent with the direct computations, particularly if taken into account that the Dutch astronomers generally omitted Mercury, for some comets Mercury and Mars and for a few comets even all the inner planets, the reduction to the barycentre, c_b, here defined as the centre of gravity of the Sun and the four inner planets, being included only.

On the basis of the same material the average value of the reduction to the centre of gravity of the Sun and the four inner planets was compared with the theoretical values, given again by formula (5), and summarized in Table 5. The consistency is again well pronounced.

Table 4

q	$\Delta\left(\frac{1}{a}\right)_q$ in 10^{-6} (a.u.)$^{-1}$					
	Theory					Direct computations
	Me	V	E	M	Total	
0	0.6	6.9	6.1	0.4	14.0	
0.5	0.4	6.9	6.1	0.4	13.8	
0.8	0.3	6.2	6.1	0.4	13.0	
1.0	0.2	5.0	6.1	0.4	11.7	
1.5	0.1	3.3	4.0	0.4	7.8	
1.72	0.1	2.9	3.5	0.4	6.9	5.7 ± 7.4
2	0.1	2.5	3.0	0.3	5.9	
3	0.1	1.7	2.0	0.2	4.0	

Table 5

r a.u.	c_b in 10^{-6} (a.u.)$^{-1}$					
	Theory					Direct computations
	Me	V	E	M	Total	
1	0.2	5.0	6.1	0.6	11.9	
2	0.1	2.5	3.0	0.3	5.9	
3	0.1	1.7	2.0	0.2	4.0	
4	0.1	1.2	1.5	0.2	3.0	
4.24	0.1	1.2	1.4	0.2	2.9	3.9 ± 4.0
5	0.0	1.0	1.2	0.1	2.3	
6	0.0	0.8	1.0	0.1	1.9	
7	0.0	0.7	0.9	0.1	1.7	

The summary of the three sections, dealing with the analysis of the accuracy in the original and future values of the semi-major axes of cometary orbits, is that the formulae given by BILO and VAN DE HULST (1960) for the average values of the difference between the original (or future) and osculating reciprocal semi-major axes and of the reduction to the barycentre are fully confirmed by direct computations. This fact together with the empirically found, close relation between the $\Delta\left(\frac{1}{a}\right)$ or c values and their root-mean-square deviations valid for the outer planets, makes it possible to reduce the values of original and future orbits published by various authors to a uniform system and to predict the additional errors arising when introducing these average corrections.

6. Corrections to the Published Values. Additional Errors

Theoretically, nearly perfect values of reciprocal semi-major axis of original and future orbits should be obtained after (1) applying the pertubations by all the nine major planets, (2) extending them to aphelion or infinity in time, and (3) reducing to the barycentre in the best sense of the word, i.e. to the centre of gravity of the Sun and the nine major planets. Such values of original and future orbits I will call hereinafter the ideal values. The reasons why even the ideal values are not more than a very good approximation, consist in the final length of the step of integration used, in the existence of cumulative errors of rounding in the course of integration, and in the omission of perturbations by all other bodies of the solar system, particularly of a few "giants" among minor planets and of hypothetical transplutonian planets. The contribution of the last ones to the barycentre of the solar system may be far from negligible. The perfect determination of the definitive orbit, or the osculating orbit at a date near to perihelion, from which the calculations of the original and future orbits start, is postulated.

For the sake of avoiding cumbrous computations, no value of original and future orbits given in practice satisfies simultaneously the three conditions for the ideal value.

To correct the published values of the original and future orbits the average corrections as given by the verified formulae (1) to (8) have been applied. The result is a probable ideal value with the root-mean-square error, or a quasi-ideal value of reciprocal semi-major axis.

The corrections for taking account of each of the three conditions have been added on the principles as follows below. The root-mean-square deviations included have been for the outer planets computed from the general empirical relation (6), for the inner planets, for which relation (6) is not valid, they have been estimated from Tables 4 and 5 for $\Delta\left(\frac{1}{a}\right)$ values and c_b values, respectively, under keeping the constant relative error.

a) Correction for the omission of perturbations by a planet of mass m_i and of its inclusion into the barycentre.

The correction for each of the outer planets is constant given by formula (3)

$$corr_1 = \frac{2m_i}{a_i}, \tag{9}$$

since no comet under observation has had its perihelion distance, q, farther from the Sun than any of the outer planets.

For the inner planets the correction is

$$corr_1 = \frac{2m_i}{z}, \tag{10}$$

where $z = \max(q, a_i)$.

The mean correction values for the outer planets and the maximum correction values for the inner planets together with the mean errors involved are given in Table 6.

Table 6

Planets	$corr_1$
J	$+367 \pm 339$
S	$+60 \pm 93$
U	$+5 \pm 15$
N	$+3 \pm 12$
P	0 ± 1
J + S	$+427 \pm 377$
U + N	$+8 \pm 22$
J + S + U + N + P	$+435 \pm 382$
Me	$+1 \pm 1$
V	$+7 \pm 9$
E	$+6 \pm 8$
M	0 ± 1
V + E	$+13 \pm 17$
Me + V + E + M	$+14 \pm 18$

b) Correction for the omission of perturbations by a planet of mass m_1.

If the planet was included into the barycentre, but the perturbations due to it were completely omitted (an often case of Pluto), the formulae of (1) or (2) are in operation:

$$corr_2 = 2m_1 \left(\frac{1}{a_1} - \frac{1}{z}\right), \qquad (11)$$

where $z = \min\,(q, a_1)$. This formula gives never a positive value. A few data are summarized in Table 7.

c) Correction for the omission of perturbations by a planet of mass m_1 from a heliocentric distance of r to aphelion or infinity.

The same formula is valid as in Case b after replacing the perihelion distance by distance r, consequently:

$$corr_3 = 2m_1 \left(\frac{1}{a_1} - \frac{1}{z}\right), \qquad (12)$$

$z = \min(r, a_1)$. For r large enough, (12) yields a zero value. Some data are included in Table 8.

d) Correction for the omission of reduction to the barycentre.

If the perturbations by a planet are applied but no reduction to the barycentre follows, the average correction should be added according to the formula:

$$corr_4 = \frac{2m_1}{r}, \qquad (13)$$

r is the heliocentric distance of stopping the integration of perturbations in the heliocentric system. Some values are comprised in Table 9.

Table 7

Planets	$corr_2$			
	$q = 0.5$	$q = 1$	$q = 2$	$q = 4$
J	-3452 ± 1677	-1544 ± 944	-588 ± 474	-110 ± 143
S	-1082 ± 733	-511 ± 422	-226 ± 240	-83 ± 117
U	-170 ± 196	-83 ± 117	-39 ± 68	-17 ± 38
N	-204 ± 223	-100 ± 134	-48 ± 79	-22 ± 46
P	-11 ± 28	-5 ± 17	-3 ± 10	-1 ± 6
J + S	-4534 ± 2037	-2055 ± 1158	-814 ± 598	-193 ± 214
U + N	-374 ± 343	-183 ± 206	-87 ± 121	-39 ± 68
J + S + U + N + P	-4919 ± 2159	-2243 ± 1233	-904 ± 645	-233 ± 245
Me	0 ± 0	0 ± 0	0 ± 0	0 ± 0
V	-3 ± 4	0 ± 0	0 ± 0	0 ± 0
E	-6 ± 8	0 ± 0	0 ± 0	0 ± 0
M	-1 ± 1	0 ± 0	0 ± 0	0 ± 0
V + E	-9 ± 12	0 ± 0	0 ± 0	0 ± 0
Me + V + E + M	-10 ± 13	0 ± 0	0 ± 0	0 ± 0

Table 8

Planets	$corr_3$			
	$r = 1$	$r = 5$	$r = 10$	$r = 25$
J	-1544 ± 944	-15 ± 35	0 ± 0	0 ± 0
S	-511 ± 422	-54 ± 86	0 ± 0	0 ± 0
U	-83 ± 117	-13 ± 31	-4 ± 14	0 ± 0
N	-100 ± 134	-17 ± 38	-7 ± 20	-1 ± 4
P	-5 ± 17	-1 ± 5	0 ± 3	0 ± 1
J + S	-2055 ± 1158	-69 ± 103	0 ± 0	0 ± 0
U + N	-183 ± 206	-30 ± 57	-11 ± 28	-1 ± 4
J + S + U + N + P	-2243 ± 1233	-100 ± 134	-11 ± 28	-1 ± 4
Me	0 ± 0	0 ± 0	0 ± 0	0 ± 0
V	0 ± 0	0 ± 0	0 ± 0	0 ± 0
E	0 ± 0	0 ± 0	0 ± 0	0 ± 0
M	0 ± 0	0 ± 0	0 ± 0	0 ± 0
V + E	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Me + V + E + M	0 ± 0	0 ± 0	0 ± 0	0 ± 0

Table 9

Planets	$corr_4$			
	$r = 1$	$r = 5$	$r = 10$	$r = 25$
J	$+1910 \pm 1099$	$+382 \pm 349$	$+191 \pm 213$	$+76 \pm 110$
S	$+571 \pm 464$	$+114 \pm 147$	$+57 \pm 90$	$+23 \pm 47$
U	$+87 \pm 121$	$+17 \pm 39$	$+9 \pm 24$	$+3 \pm 12$
N	$+104 \pm 138$	$+21 \pm 44$	$+10 \pm 26$	$+4 \pm 13$
P	$+6 \pm 17$	$+1 \pm 5$	$+1 \pm 3$	0 ± 2
J + S	$+2481 \pm 1325$	$+496 \pm 420$	$+248 \pm 256$	$+99 + 133$
U + N	$+191 \pm 213$	$+38 + 67$	$+19 \pm 41$	$+8 \pm 21$
J + S + U + N + P	$+2678 \pm 1399$	$+535 \pm 443$	$+268 \pm 271$	$+107 \pm 141$
Me	0 ± 0	0 ± 0	0 ± 0	0 ± 0
V	$+5 \pm 5$	$+1 \pm 1$	0 ± 1	0 ± 0
E	$+6 \pm 6$	$+1 \pm 1$	$+1 \pm 1$	0 ± 0
M	$+1 \pm 1$	0 ± 0	0 ± 0	0 ± 0
V + E	$+11 \pm 11$	$+2 \pm 2$	$+1 \pm 1$	0 ± 0
Me + V + E + M	$+12 \pm 12$	$+2 \pm 2$	$+1 \pm 1$	0 ± 0

All the data included in Tables 6 to 9, are analogously to the preceding tables given in the 10^{-6} units of $(\text{a.u.})^{-1}$. The quasi-ideal value of reciprocal semi-major axis of the original or future comet orbit is then given by:

$$\left(\frac{1}{a_b}\right)_{qu} = \left(\frac{1}{a_b}\right)_{publ} + \sum_{i=1}^{4} corr_i \,, \qquad (14)$$

$\left(\frac{1}{a_b}\right)_{publ}$ is the published value, and the total additional error, δ_{qu}, results from:

$$\delta_{qu}^2 = \sum_{i=1}^{4} \delta_i^2 \,, \qquad (15)$$

δ_i are the corresponding root-mean-square deviations derived in accordance with the working instruction mentioned at the beginning of this section.

7. Catalogue Values and Their Mean Errors

In this Catalogue I endeavour to give the resulting values of reciprocal semi-major axis as close to the ideal values as possible. They are included in columns headed "Catalogue Values".

For the comet's original or future orbit, which the only $\left(\frac{1}{a}\right)$ value has up to now been published for, the catalogue value is identical with the quasi-ideal value computed from the published value, as described in the foregoing section:

$$\left(\frac{1}{a_b}\right)_{cat} = \left(\frac{1}{a_b}\right)_{qu} . \tag{16}$$

The mean error of the catalogue value, δ_{cat}, is defined by

$$\delta^2_{cat} = \delta^2_{def} + \delta^2_{qu} , \tag{17}$$

δ_{def} is the mean error of the reciprocal semi-major axis of the definitive orbit.

If more values of $\left(\frac{1}{a_b}\right)$ are published, the catalogue value is derived as the weighed mean of the quasi-ideal values computed from the values published:

$$\left.\begin{aligned}
\left(\frac{1}{a_b}\right)_{qu_j} &= \left(\frac{1}{a_b}\right)_{publ_j} + \sum_{i=1}^{4} corr_{j,i} \\
\delta^2_{qu_j} &= \sum_{i=1}^{4} \delta^2_{j,i} \\
p_j &= \frac{1}{\delta^2_{qu_j}} \\
p = \sum_{j=1}^{n} p_j &= \sum_{j=1}^{n} \frac{1}{\sum_{i=1}^{4} \delta^2_{j,i}} \\
\left(\frac{1}{a_b}\right)_{cat} &= \frac{1}{p} \sum_{j=1}^{n} p_j \left(\frac{1}{a_b}\right)_{qu_j} \\
\delta^2_{cat} &= \delta^2_{def} + \frac{1}{p} ,
\end{aligned}\right\} \tag{18}$$

where most symbols are the same as those in the foregoing section, n is the number of $\left(\frac{1}{a_b}\right)$ values published, p_j and δ_{qu_j} are the weights and mean errors of the respective quasi-ideal values and p the weight of the catalogue value. If $\delta_{qu_k} = 0$ for any $k \leq n$, then

$$\left(\frac{1}{a_b}\right)_{cat} = \left(\frac{1}{a_b}\right)_{qu_k} , \tag{19}$$

and

$$\delta_{cat} = \delta_{def} .$$

The catalogue value of $\left(\frac{1}{a_b}\right)$ of the original or future orbit depends, of course, on the $\left(\frac{1}{a}\right)$ value of the definitive orbit. If any of the published $\frac{1}{a_b}$ values of the original or future orbit was based on another definitive orbit of the same date of osculation, it was referred to the definitive orbit given in the Catalogue before quoted in the respective column of the Catalogue, according to the formula:

$$\left(\frac{1}{a_b}\right)_{publ} = \left(\frac{1}{a_b}\right)'_{publ} + \left(\frac{1}{a}\right)_{def} - \left(\frac{1}{a}\right)'_{def}, \tag{21}$$

$\left(\frac{1}{a_b}\right)'_{publ}$ is the value of the original or future orbit published in the original paper, based on the definitive orbit of $\left(\frac{1}{a}\right)'_{def}$, $\left(\frac{1}{a}\right)_{def}$ is the value of the definitive orbit adopted in the Catalogue.

8. Accuracy of the Data Included in the Catalogue

In the comments on the Catalogue the formal accuracy, i.e. the number of decimals, will be noted to which the data of each of the magnitudes included in the Catalogue are given.

The elements of the definitive orbit are given with a standard number of decimals, i.e. with four decimals for the angular elements, with five decimals for the time element and with six decimals for the elements indicating the form of the orbit.

The mean residual of the normal place of unit weight is given with the same number of decimals as the normal places themselves are usually published.

The vector elements are given to six decimals, since the change of any angular element by $\pm 1''$ can yield a change just in the sixth decimal of the vector elements, on an average.

Concerning the spherical co-ordinates of the perihelion and of the orbital pole, their accuracy given is $\pm 0^\circ.01$ since this is the limit of the reasonable number of decimals for the galactic co-ordinates.

As to the number of decimals of the values of true anomaly and the other magnitudes being in connection with it, both of the definitive orbit and of the original and future orbits, differential formulae are used to ensure the formal accuracies of the related magnitudes to be comparable.

A characteristic of the reliability of the definitive orbit is the length of the period of observation, usually given with an accuracy to one day. Since the definitive elements are, as a rule, derived from an arc of orbit very close to the perihelion, the differential formula of parabolic motion gives the following relation between the change in true anomaly and in the length of period of observation for heliocentric distances close to q:

$$dv = 1.4\, q^{-3/2}\, dt, \tag{22}$$

dt is expressed in days, dv results in degrees. The mean value of q for the comets included in the Catalogue is approximately 1.4 a.u., so that a change of $dt = 1$ day yields a change of $dv = 0^\circ.9$. Therefore it is enough to give the true-anomaly values for definitive orbits with a formal accuracy to 1°.

True anomaly is used by some authors, while time by other as the integration variable in the course of the computations of original and future orbits. Keeping e.g. the former manner we can derive formulae interrelating dv, dt and dr. At large heliocentric distances, however, somewhat different relations are valid to (22). Neglecting terms with $\frac{q}{r}$ in comparison with a unit we can find:

$$\left.\begin{aligned} dt &= 0.002 \frac{r^2}{\sqrt{q}}\, dv\,, \\ dr &= 0.017 \sqrt{\frac{r^3}{q}}\, dv\,, \end{aligned}\right\} \quad (23)$$

dv is expressed in degrees, dt results in years, dr, in a.u. Owing to a slight change of v at large distances, its formal accuracy accepted is an order higher than earlier, i.e. 0°.1. The corresponding differential variations in the two other magnitudes is for a few heliocentric distances given in Table 10. The accuracy adopted in the Catalogue,

Table 10

r	dv = 0° . 1	
	dr	dt
10	0.04	0.02
25	0.18	0.11
50	0.50	0.42
100	1.4	1.7

dr = 0.1 a.u. and dt = 0.1 year will obviously represent a reasonable average in the wide range of heliocentric distances.

The accuracy of the catalogue values of original and future comet orbits was thoroughly discussed in a few preceding sections. The reciprocal semi-major axis of any orbit is in the Catalogue given to six decimals.

9. Comments on the Catalogue

The Catalogue contains 150 data on original orbits of 81 comets and 91 data on future orbits of 70 comets, mostly members of the group of so-called new and fairly new comets (Oort, Schmidt 1951). Only five or six comets belong to the group of old comets, while about 63 per cent of the total move in hyperbolic orbits relative to the Sun in its proximity.

The Catalogue consists of six parts: the first two parts deal completely with the definitive orbit, from which both original and future orbits are computed. Parts C and D comprise the data on the space orientation of the definitive orbit (and with a sufficient accuracy also that of the original and future orbits), and make it possible to study the direction of the comet's motion in the far past or future. The last two parts give the comet's original and future orbits, respectively.

The detailed contents of the respective parts is as follows:

Part A. Basic Data on the Definitive Orbit

The first part includes the designation of the comet and the elements of its orbit referred to a date close to the date of perihelion passage, i.e. of its definitive orbit. If more definitive orbits have been available, that was perferred having the most favourable characteristics of the reliability and accuracy of its determination (see Part B).

Individual columns of Part A indicate:

Column A.1: Definitive Comet's Designation

The definitive designation of the comet consists of the year of perihelion passage and of the roman numeral giving its order within the year. This column is identical with columns B.1, C.1, D.1, E.1 and F.1.

Column A.2: Preliminary Comet's Designation

The preliminary designation of the comet consists of the year of discovery and of the letter giving its order within the year.

Column A.3: Nominal Comet's Designation

The nominal designation of the comet is identical with the name of the discoverer (or discoverers). If no discoverer is known, his name is replaced by a "sobriquet" as given in PORTER'S Catalogue (PORTER 1961).

Column A.4: T_{osc}

Time of osculation. Both before and after 1925.0 the time of osculation is expressed in U.T., i.e. for any comet before 1925.0 a constant of 0.5 day is added to the date given in G.M.T., or a constant of 0.46279 day to the date given in B.M.T. For a few recent comets the osculation time is given in the Ephemeris Time and then "*E*" is added. If no osculation time is given, see the respective note.

Column A.5: T

Time of perihelion passage. The same principles are valid as for the time of osculation. Formal accuracy to five decimals.

Columns A.6 to A.8: ω Ω i

Argument of perihelion, ascending node, inclination of orbit. The angular ecliptic elements of the orbit are referred to equinox 1950.0. Formal accuracy to four decimals.

Column A.9: q

Perihelion distance, expressed in astronomical units. Formal accuracy to six decimals.

Column A.10: e

Eccentricity of the orbit. Formal accuracy to six decimals.

Part B. Derived Elements. Characteristics of the Accuracy of the Definitive Orbit. Reference to the Definitive Orbit

Individual columns of Part B indicate:

Column B.1: Definitive Comet's Designation

See Column A.1.

Column B.2: $\left(\frac{1}{a}\right)_{\text{osc}}$

Reciprocal semi-major axis of the definitive orbit with the root-mean-square error. Formal accuracy to six decimals.

Column B.3: P

Orbital period, its most probable value for elliptical orbits (in years).

Column B.4: Perturbing Planets

Perturbing planets, taken into account in the course of calculations. Current abbreviations are used. If no planet is given see the respective note.

Columns B.5 to B.6: v_1 v_2

True anomaly of the first and the last positions applied for computing the definitive orbit. Formal accuracy to one degree.

Column B.7: int v

Interval of true anomalies, or the heliocentric arc of the comet's orbit applied for the calculations. Formal accuracy to one degree.

Column B.8: int obs.

Period of observation, the time distance between the first and the last observations included, in days. Formal accuracy to one day.

Column B.9: N

The total number of observations made use of, when computed the definitive orbit. Only the observations actually applied are included though only in one coordinate. Those originally considered but before forming normal places rejected, are not involved in this column.

Column B.10: ε

Mean residual of the normal place of unit weight; for comets 1912 II and 1944 I the mean residual of a single observation is given. Formal accuracy is tabulated as given by the author of the definitive orbit, but never to more than $0''.01$. If no residual is given, see the respective note, and if no remark is present, I have not succeeded in getting acquainted with the original paper and I do not know if there is any possibility of establishing the residual.

Column B.11: Reference

Reference to the original paper comprising the determination of the definitive orbit.

Part C. Vector Elements

The vector elements are computed from the angular elements of the definitive orbit of Part A and referred, consequently, to equinox 1950.0. Individual columns of Part C give:

Column C.1: Definitive Comet's Designation

See Column A.1.

Columns C.2 to C.4: P_x P_y P_z

Rectangular equatoreal components of the unit vector to the perihelion. Formal accuracy to six decimals.

Columns C.5 to C.7: Q_x Q_y Q_z

Rectangular equatoreal components of the unit vector to the position of true anomaly of +90°. Formal accuracy to six decimals.

Columns C.8 to C.10: R_x R_y R_z

Rectangular equatoreal components of the unit vector to the "northern" pole of the orbit. Formal accuracy to six decimals.

Part D. Directions to the Perihelion and Orbital Pole

Spherical co-ordinates are given of the two directions referred to the centre of the Sun and to equinox 1950.0. The individual columns indicate:

Column D.1: Definitive Comet's Designation

See Column A.1.

Columns D.2 to D.7: α_π δ_π λ_π β_π l_π^{II} b_π^{II}

Angular equatoreal, ecliptical and galactic co-ordinates of the perihelion: right ascension, declination, celestial longitude, celestial latitude, galactic longitude and galactic latitude. Formal accuracy to 0°.01.

Columns D.8 to D.13: α_p δ_p λ_p β_p l_p^{II} b_p^{II}

Angular equatoreal, ecliptical and galactic co-ordinates of the "northern" orbital pole: right ascension, declination, celestial longitude, celestial latitude, galactic longitude and galactic latitude. Formal accuracy to 0°.01.

Part E. Original Values of Reciprocal Semi-major Axis

The published so far and catalogue original orbits are included. Columns E.2 to E.7 concern the published values and they are, in fact, the survey of original values of the comet's reciprocal semi-major axis published so far by various authors. Columns E.8 to E.9 concern the catalogue values. The individual columns indicate:

Column E.1: Definitive Comet's Designation

See Column A.1.

Column E.2: $\left(\frac{1}{a_b}\right)_{orig}$

Published original value of the reciprocal semi-major axis in the barycentric system. Formal accuracy to six decimals.

Column E.3: Perturbing Planets

Perturbing planets considered during the computations. Perturbations by the inner planets applied only within the interval of not more than a year or a few years at the most. Current abbreviations of the planets are used. If no planet is given, see the respective note.

Column E.4: v_{orig}

True anomaly corresponding to the beginning of the period of integration, T_{orig}. Formal accuracy to 0°.1.

Column E.5: r_{orig}

Heliocentric distance corresponding to the beginning of the period of integration. Formal accuracy to 0.1 a.u.

Column E.6: int pert.

The length of the period of integration of the planetary perturbations, defined by

$$\text{int pert.} = T_{\text{osc}} - T_{\text{orig}} .$$

Formal accuracy to 0.1 year.

Column E.7: Reference

Reference to the original paper comprising the determination of the original orbit.

Column E.8: catalogue value $\left(\frac{1}{a_{\text{b}}}\right)_{\text{orig}}$

Resulting original value of the reciprocal semi-major axis in the barycentric system adopted in the General Catalogue with its root-mean-square error. Formal accuracy to six decimals.

Column E.9: catalogue value $\left(\frac{1}{a_{\text{b}}}\right)_{\text{orig}} - \left(\frac{1}{a}\right)_{\text{osc}}$

Resulting difference between the barycentric original value and the heliocentric osculating value of the reciprocal semi-major axis. The positive sign indicates an acceleration of the approaching comet, the negative sign its deceleration. Formal accuracy to six decimals.

Part F. Future Values of Reciprocal Semi-major Axis

The published so far and catalogue future orbits are included. Columns F.2 to F.7 concern the published values and they are, in fact, the survey of future values of the comet's reciprocal semi-major axis published so far by various authors. Columns F.8 to F.10 concern the catalogue values. The individual columns show:

Column F.1: Definitive Comet's Designation

See Column A.1.

Column F.2: $\left(\frac{1}{a_{\text{b}}}\right)_{\text{fut}}$

Published future value of the reciprocal semi-major axis in the barycentric system. Formal accuracy to six decimals.

Column F.3: Perturbing Planets

Perturbing planets considered during the computations. Perturbations by the inner planets applied only within the interval of not more than a year or a few years at the most. Current abbreviations of the planets are used.

Column F.4: v_{fut}

True anomaly, corresponding to the end of the period of integration, T_{fut}. Formal accuracy to 0°.1.

Column F.5: r_{fut}

Heliocentric distance corresponding to the end of the period of integration. Formal accuracy to 0.1 a.u.

Column F.6: int pert.

The length of the period of integration of the planetary perturbations, defined by

$$\text{int pert.} = T_{\text{fut}} - T_{\text{osc}} .$$

Formal accuracy to 0.1 year.

Column F.7: Reference

Reference to the original paper comprising the determination of the future orbit.

Column F.8: catalogue value $\left(\frac{1}{a_b}\right)_{fut}$

Resulting future value of the reciprocal semi-major axis in the barycentric system adopted in the General Catalogue with its root-mean-square error. Formal accuracy to six decimals.

Column F.9: catalogue value $\left(\frac{1}{a}\right)_{osc} - \left(\frac{1}{a_b}\right)_{fut}$

Resulting difference between the heliocentric osculating value and the barycentric future value of the reciprocal semi-major axis. The positive sign indicates an acceleration of the receding comet, the negative sign its deceleration. Formal accuracy to six decimals.

Column F.10: catalogue value $\left(\frac{1}{a_b}\right)_{orig} - \left(\frac{1}{a_b}\right)_{fut}$

Resulting difference between the barycentric original and future values of the reciprocal semi-major axis. The positive sign indicates an acceleration of the comet during its penetration into the inner parts of the solar system, the negative sign its deceleration. Formal accuracy to six decimals.

10. Distribution of the Energy-changes of Comets through Planetary Action

The differences given in the last columns of Part E and F of the General Catalogue represent, in fact, the energy-changes of comets in the course of their pass through the inner parts of the solar system. Designing successively

$$\left.\begin{aligned} \varDelta\left(\frac{1}{a}\right)_{tot} &= \left(\frac{1}{a_b}\right)_{orig} - \left(\frac{1}{a_b}\right)_{fut}, \\ \varDelta\left(\frac{1}{a}\right)_{orig} &= \left(\frac{1}{a_b}\right)_{orig} - \left(\frac{1}{a}\right)_{q}, \\ \varDelta\left(\frac{1}{a}\right)_{fut} &= -\left[\left(\frac{1}{a}\right)_{q} - \left(\frac{1}{a_b}\right)_{fut}\right], \end{aligned}\right\} \quad (24)$$

$\left(\frac{1}{a}\right)_q$ is the osculating value of $\frac{1}{a}$ referred to the perihelion passage in the heliocentric system of co-ordinates, and designing, moreover, $\varDelta\left(\frac{1}{a}\right)_{orig}$ and $\varDelta\left(\frac{1}{a}\right)_{fut}$ as $\varDelta\left(\frac{1}{a}\right)$ if not distinguished between original and future orbits, we can obtain a mean, statistical value of the three differences from the best material available at present and compare it both with results of some theoretical considerations and with earlier derived values.

The distributions of $\Delta\left(\frac{1}{a}\right)_{\mathrm{orig}}$, $\Delta\left(\frac{1}{a}\right)_{\mathrm{fut}}$ and the sum of them, $\Delta\left(\frac{1}{a}\right)$, are represented in Fig. 3. There are well pronounced differences between the three distributions, summarized in Table 11. For each of them the individual columns give: the mean value, the root-mean-square deviation and the number of individual orbits included.

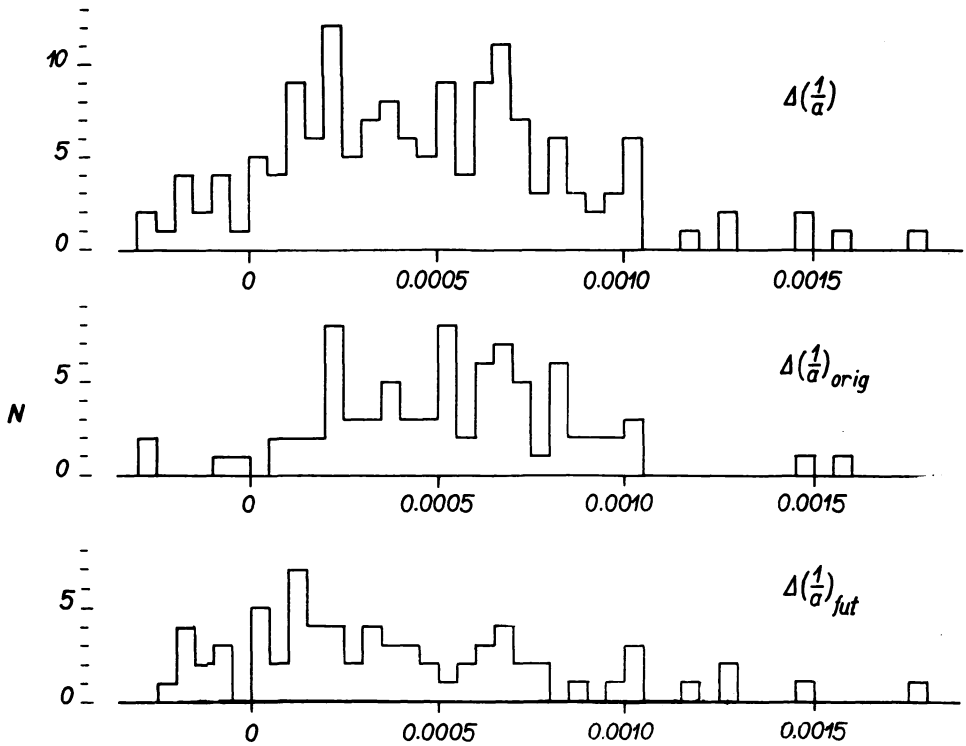


Fig. 3. *The distribution of energy-changes of comets through planetary action: original and future orbits in the upper panel, original orbits in the middle panel and future orbits in the lower panel.*

The distribution of $\Delta\left(\frac{1}{a}\right)$ is closest to the Gaussian distribution. This is fully confirmed by Fig. 4, where the logarithm of the number of deviations is plotted against the square of the deviations. The slope of the relation, B, is related to the root-mean-square deviation, σ, since:

$$\sigma = \left(-\frac{\log e}{2.B}\right)^{1/2}. \tag{25}$$

With $B = -1.420$ it is

$$\sigma = \pm 0.000391 \tag{26}$$

in a very good agreement with the tabulated value.

Table 11

Distribution	Mean value	Root-mean-sq. deviation	Number
$\Delta\left(\frac{1}{a}\right)_{\text{orig}}$	+0.000532	±0.000335	81
$\Delta\left(\frac{1}{a}\right)_{\text{fut}}$	+0.000396	±0.000426	70
$\Delta\left(\frac{1}{a}\right)$	+0.000469	±0.000384	151

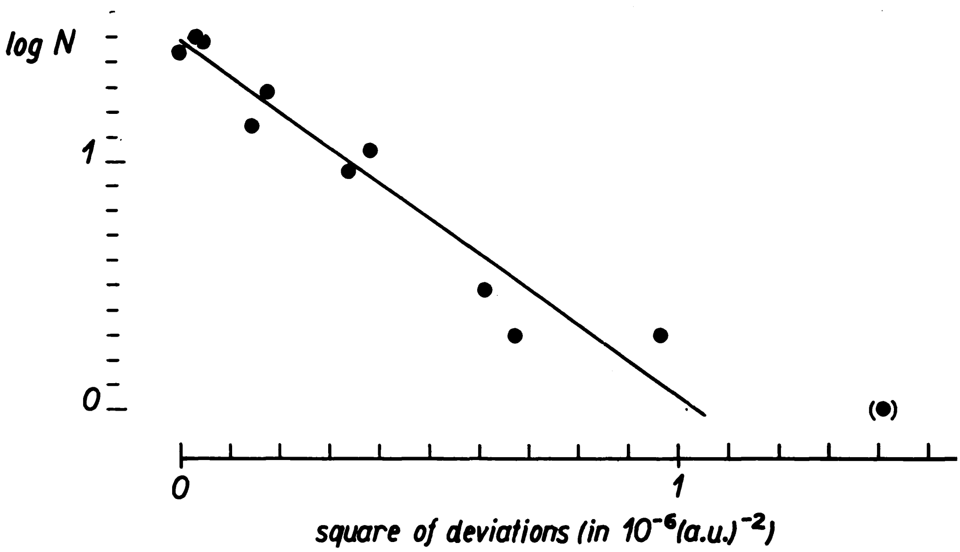


Fig. 4. *Frequency of orbits in dependence on the square of deviations from the mean energy-change. The slope indicates the root-mean-square deviation.*

The mean theoretical values of $\Delta\left(\frac{1}{a}\right)$ resulting from BILO's and VAN DE HULST's theory may simply be deduced from Part (a) of Section 6 of this paper. It indicates a slight dependence on the perihelion distance, summarized in Table 12. The root-mean-square deviation is interpolated from the empirical relation (6).

There is really nearly perfect agreement between the theory and the Catalogue not only as for the $\Delta\left(\frac{1}{a}\right)$ value itself, but as well as for its root-mean-square deviation. It should be remarked that a value of +0.000449 was from similar considerations

Table 12

q	$\Delta\left(\frac{1}{a}\right)$ theoretical
0	$+0.000449 \pm 0.000382$
0.5	$+0.000448 \pm 0.000382$
1	$+0.000446 \pm 0.000382$
1.5	$+0.000443 \pm 0.000382$
2	$+0.000441 \pm 0.000382$
3	$+0.000439 \pm 0.000382$
4	$+0.000438 \pm 0.000382$

derived by FABRY as early as in 1894 (FABRY 1894). SINDING came later on (SINDING 1948) to a result a factor 3/2 higher, criticized by BILO and VAN DE HULST (ibid.).

FAYET'S approximate computations of original orbits lead to an average value of $+0.000459$ (DIRIKIS 1956), in practice identical with ours.

SINDING found from accurate determinations of 21 comets a value of $+0.000552$ (SINDING 1948), and DIRIKIS from the extended list even a larger one. It should be emphasized that all these values were derived from statistics of original orbits only.

LYTTLETON and HAMMERSLEY (1963) derived from the list of original and future orbits, compiled by MARSDEN, a difference of 0.000175 between $\Delta\left(\frac{1}{a}\right)_{orig}$ and $\Delta\left(\frac{1}{a}\right)_{fut}$. They first mentioned that the value of $\Delta\left(\frac{1}{a}\right)$ derived from future orbits is more correct than that from original orbits. Original orbits are almost certainly influenced by selection, because the comets investigated were mostly ones with hyperbolic osculating orbits near perihelion and therefore inclined to greater than average energy-change due to planetary action. This was supported by the data given by the two authors, by KENDALL (1961) and is anew confirmed by Table 11 of this paper. The survey of all the determinations of $\Delta\left(\frac{1}{a}\right)$ discussed here is included in Table 13. The individual columns give: the mean value of $\Delta\left(\frac{1}{a}\right)$, the method used, the references and a remark indicating which planets were taken into account at the considerations if a theoretical way was followed, or how many original or future orbits were applied if a statistical way was used. It should be added that there is no difference theoretically between the average values of $\Delta\left(\frac{1}{a}\right)_{orig}$ and $\Delta\left(\frac{1}{a}\right)_{fut}$.

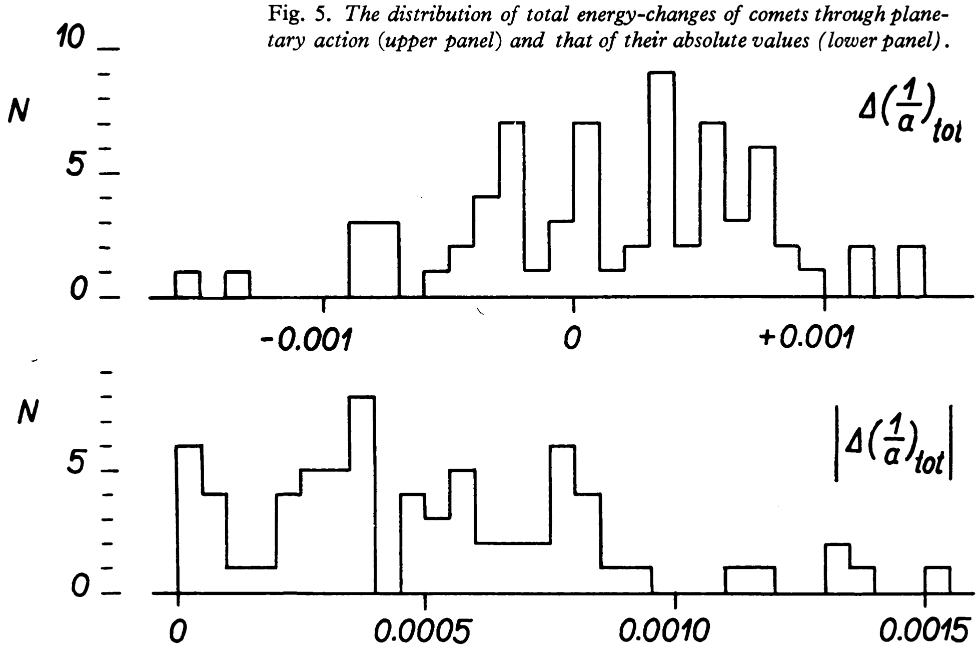
The distribution of total energy-changes of comets during their penetration into the inner parts of the solar system, given by $\Delta\left(\frac{1}{a}\right)_{tot}$, is represented in the upper panel of Fig. 5. The mean value is

$$+0.000152 \pm 0.000607$$

Table 13

	$\Delta\left(\frac{1}{a}\right)$	Method	References	Remark
1	+0.000449	theoretical	Fabry (1894)	ME, V, E, M, J, S, U, N
2	+0.000459	statistical	Fayet (1910), Dirkis (1956)	145 approximate original orbits
3	+0.000552	statistical	Sinding (1948)	21 rigorous original orbits
4	+0.000544	theoretical	Sinding (1948)	J
5	+0.000633	theoretical	Sinping (1948), Dirikis (1956)	J, S
6	+0.000602	statistical	Dirikis (1956)	26 rigorous original orbits
7	+0.000435	theoretical	Bilo, van de Hulst (1960), present paper	J, S, U, N, P
8	+0.000438 to +0.000449	theoretical	Bilo, van de Hulst (1960), present paper	Me, V, E, M, J, S, U, N, P
9	+0.000630	statistical	Lyttleton Hammersley (1963)	39 rigorous original orbits
10	+0.000455	statistical	Lyttleton, Hammersley (1963)	21 rigorous future orbits
11	+0.000532	statistical	present paper	81 rigorous original orbits
12	+0.000396	statistical	present paper	70 rigorous future orbits
13	+0.000469	statistical	present paper	151 rigorous original and future orbits

Fig. 5. *The distribution of total energy-changes of comets through planetary action (upper panel) and that of their absolute values (lower panel).*



as results from 70 original and future orbits. This value is close to another one, +0.000233, obtained from 18 comets by LYTTLETON and HAMMERSLEY (1963). Theoretical considerations give a zero value for the average total energy-change, and the difference is again probably due to the effect suggested by LYTTLETON and HAMMERSLEY (ibid.).

VAN WOERKOM (1948) theoretically estimated the average variation in $\frac{1}{a}$ during the pass of a comet through the planetary system. He took only Jupiter's influence into account and found an absolute mean variation of 0.00053 for comets approaching the Earth's orbit and a variation of 0.00071 for comets with $q = 4.5$ a.u. To verify his conclusions the distribution of $\left|\Delta\left(\frac{1}{a}\right)_{\mathrm{tot}}\right|$ has also been investigated, given at the lower panel of Fig. 5, the resulting mean value from the 70 comets being

$$0.000509 \pm 0.000357\,,$$

i.e. somewhat smaller than VAN WOERKOM'S results.

II. Probability of Interstellar Original and Future Orbits

It is a generally known fact that nearly all original orbits investigated so far have been ellipsae. Together with it, however, another general feature is apparent in possibly all the papers dealing with the determination of original orbits or at least with their statistics: the authors are extremely distrustful of any value of original orbit indicating an interstellar origin of the comet. This perhaps is reasonable if the error involved is greater or comparable with the value itself, but hardly comprehensible in the case, when the value is greater a factor of, say, three or more than the error involved. Neither is any reason for fulfilling any requirement concerning the length of the period of observation, since the shorter period of observation is followed by an increase in the error of the reciprocal semi-major axis, as seen from Part B of the Catalogue. The important criterion, on the other hand, is whether the distributions of residuals in right ascension and declination are of random character, which are usually not, unfortunately, investigated by authors of definitive orbits. If this condition is fulfilled — and it is obviously in most cases — then both the error of the reciprocal semi-major axis of the definitive orbit and that of the additional correction (being, however, mostly very small compared with the former) have character of a random variable as well. If, in spite of it, an original orbit of, say, -0.000060 ± 0.000035 (a.u.)$^{-1}$ is considered as a hardly hyperbolic orbit, while another one, of $+0.000060 \pm 0.000035$ (a.u.)$^{-1}$ as an undoubtedly elliptical, then there is no reason for publishing the errors of the orbital elements any longer.

To be "equitable" to both elliptical and hyperbolic orbits I compute the probability of interstellar character of original and future comet orbits. The computation is based on the Gaussian distribution, characterized by the most probable value, $\left(\frac{1}{a_0}\right)$, and the root-mean-square deviation, σ:

$$p = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{\frac{1}{\sigma\sqrt{2}}\left(\frac{2}{H} - \frac{1}{a_0}\right)} \exp(-Z^2)\, dZ\,, \qquad (26)$$

where H is the semi-diameter of the sphere of action of the solar system. As I show in another paper, unpublished so far, this sphere is strongly deformed, its dimensions varying at the present time from 0.6 parsec to about 3 parsecs, or from 120,000 a.u. to 620,000 a.u. The results are published in Table 14 for original orbits and in Table 15 for future orbits. A probability value is given for each comet with known root-mean-square error of its definitive orbit and for a few values of H, including an infinite sphere of action, the most unfavourable event from the viewpoint of interstellar orbits. Table 14 shows that interstellar original orbits have to be conceded to at least the four following comets: 1886 III, 1899 I, 1944 I and 1960 II. Five other comets, namely 1890 III, 1893 I, 1911 IV, 1946 I and 1959 III are under strong suspicion of having interstellar character (probability higher than 0.9) and a number of other under a weaker suspicion.

As for the future comet orbits a well-known effect is supported that about 40 per cent of the comets investigated will escape from the planetary system into interstellar space.

A detailed study of the probability distributions of the reciprocal semi-major axes of original and future comet orbits will be presented in another paper of mine in the near future.

Most of the derived data, included in the General Catalogue (Parts C and D completely, some columns of Parts E and F) as well as figures included in some tables (particularly Tables 14 and 15) were computed on Zuse Z23 computers, of the Computing Centre of the ČKD Praha, and of the State Institute for Engine Construction, Prague.

Table 14

Comet	Probability of interstellar original orbit			
	$H = 0.48$ pc	$H = 0.97$ pc	$H = 2.4$ pc	$H = \infty$
1844 II	0.00	0.00	0.00	0.00
1853 III	0.11	0.04	0.02	0.01
1863 I	0.00	0.00	0.00	0.00
1863 VI	0.40	0.33	0.28	0.26
1864 III	0.00	0.00	0.00	0.00
1873 V	0.00	0.00	0.00	0.00
1880 II	0.09	0.09	0.09	0.09
1882 I	0.00	0.00	0.00	0.00
1882 II	0.00	0.00	0.00	0.00
1886 I	0.87	0.75	0.66	0.59
1886 II	0.00	0.00	0.00	0.00
1886 III	1.00	1.00	1.00	1.00
1886 IX	0.01	0.00	0.00	0.00
1889 I	0.40	0.34	0.31	0.28
1889 II	0.00	0.00	0.00	0.00
1890 II	0.00	0.00	0.00	0.00
1890 III	0.94	0.94	0.94	0.94
1892 I	0.00	0.00	0.00	0.00
1892 II	0.00	0.00	0.00	0.00
1893 I	0.92	0.92	0.92	0.92
1896 I	0.68	0.67	0.67	0.66
1897 I	0.27	0.21	0.17	0.15
1898 I	0.00	0.00	0.00	0.00
1898 VII	0.96	0.79	0.58	0.42
1898 VIII	0.63	0.59	0.56	0.54
1898 X	0.00	0.00	0.00	0.00
1899 I	1.00	1.00	1.00	1.00
1900 II	0.00	0.00	0.00	0.00
1901 I	0.08	0.08	0.08	0.08
1902 III	0.35	0.17	0.10	0.07
1904 I	0.00	0.00	0.00	0.00
1904 II	0.11	0.07	0.05	0.04
1905 IV	0.01	0.00	0.00	0.00
1905 V	0.05	0.05	0.04	0.04
1905 VI	0.00	0.00	0.00	0.00
1907 I	0.38	0.29	0.24	0.21
1908 III	0.04	0.03	0.02	0.02

Table 14 (cont.)

Comet	Probability of interstellar original orbit			
	$H = 0.48$ pc	$H = 0.97$ pc	$H = 2.4$ pc	$H = \infty$
1910 I	0.00	0.00	0.00	0.00
1910 III	0.00	0.00	0.00	0.00
1911 IV	0.97	0.96	0.95	0.95
1912 II	0.00	0.00	0.00	0.00
1914 III	0.90	0.87	0.86	0.85
1914 V	0.25	0.00	0.00	0.00
1915 II	0.03	0.02	0.02	0.01
1917 III	0.67	0.16	0.03	0.01
1919 V	0.53	0.46	0.41	0.39
1922 II	0.83	0.66	0.54	0.46
1925 I	0.14	0.08	0.05	0.04
1925 VI	0.00	0.00	0.00	0.00
1925 VII	0.29	0.17	0.11	0.09
1927 IV	0.00	0.00	0.00	0.00
1930 IV	0.00	0.00	0.00	0.00
1932 VI	0.00	0.00	0.00	0.00
1936 I	0.33	0.32	0.31	0.30
1937 IV	0.05	0.02	0.01	0.00
1941 VIII	0.00	0.00	0.00	0.00
1942 IV	0.00	0.00	0.00	0.00
1944 I	1.00	1.00	1.00	1.00
1944 IV	0.86	0.67	0.52	0.43
1946 I	1.00	0.99	0.96	0.93
1946 VI	0.09	0.03	0.01	0.01
1948 I	0.00	0.00	0.00	0.00
1948 XI	0.00	0.00	0.00	0.00
1949 I	0.00	0.00	0.00	0.00
1949 IV	0.00	0.00	0.00	0.00
1950 I	0.00	0.00	0.00	0.00
1951 I	0.01	0.00	0.00	0.00
1953 III	0.00	0.00	0.00	0.00
1954 V	0.00	0.00	0.00	0.00
1955 IV	0.00	0.00	0.00	0.00
1957 V	0.00	0.00	0.00	0.00
1958 III	0.00	0.00	0.00	0.00
1959 III	0.99	0.99	0.98	0.98
1960 II	1.00	1.00	1.00	1.00

Table 15

Comet	Probability of interstellar future orbit			
	$H = 0.48$ pc	$H = 0.97$ pc	$H = 2.4$ pc	$H = \infty$
1844 II	0.00	0.00	0.00	0.00
1853 III	1.00	1.00	1.00	1.00
1863 VI	0.00	0.00	0.00	0.00
1864 III	0.00	0.00	0.00	0.00
1873 V	0.00	0.00	0.00	0.00
1880 II	0.62	0.61	0.61	0.60
1886 I	1.00	1.00	1.00	1.00
1886 II	1.00	1.00	1.00	1.00
1886 III	1.00	1.00	1.00	1.00
1886 IX	0.16	0.09	0.06	0.04
1889 I	1.00	1.00	1.00	1.00
1889 II	0.00	0.00	0.00	0.00
1890 II	0.00	0.00	0.00	0.00
1890 III	0.95	0.95	0.95	0.95
1892 I	0.00	0.00	0.00	0.00
1892 II	0.00	0.00	0.00	0.00
1893 I	0.98	0.97	0.97	0.97
1896 I	0.95	0.95	0.95	0.95
1897 I	1.00	1.00	1.00	1.00
1898 I	0.00	0.00	0.00	0.00
1898 VII	1.00	1.00	1.00	1.00
1898 VIII	0.00	0.00	0.00	0.00
1898 X	0.05	0.04	0.04	0.04
1899 I	1.00	1.00	1.00	1.00
1900 II	1.00	1.00	1.00	1.00
1901 I	0.09	0.09	0.09	0.08
1902 III	0.00	0.00	0.00	0.00
1904 I	0.00	0.00	0.00	0.00
1904 II	0.00	0.00	0.00	0.00
1905 IV	1.00	1.00	1.00	1.00
1905 V	0.65	0.62	0.61	0.60
1907 I	1.00	1.00	1.00	1.00
1908 III	1.00	1.00	1.00	1.00
1910 I	0.00	0.00	0.00	0.00
1911 IV	0.16	0.14	0.13	0.12
1912 II	0.00	0.00	0.00	0.00
1914 III	0.96	0.95	0.94	0.94

Table 15 (cont.)

Comet	Probability of interstellar future orbit			
	H = 0.48 pc	H = 0.97 pc	H = 2.4 pc	$H = \infty$
1914 V	0.00	0.00	0.00	0.00
1915 II	0.00	0.00	0.00	0.00
1917 III	0.00	0.00	0.00	0.00
1919 V	0.86	0.82	0.79	0.77
1922 II	1.00	1.00	1.00	1.00
1925 I	1.00	1.00	1.00	1.00
1925 VI	0.00	0.00	0.00	0.00
1925 VII	1.00	1.00	1.00	1.00
1927 IV	0.00	0.00	0.00	0.00
1930 IV	1.00	1.00	1.00	0.99
1932 VI	1.00	1.00	1.00	1.00
1936 I	0.92	0.91	0.91	0.91
1937 IV	0.00	0.00	0.00	0.00
1942 IV	1.00	1.00	1.00	1.00
1944 IV	1.00	1.00	1.00	1.00
1946 I	0.00	0.00	0.00	0.00
1946 VI	0.50	0.29	0.19	0.13
1948 I	1.00	1.00	1.00	1.00
1948 XI	0.00	0.00	0.00	0.00
1949 I	0.00	0.00	0.00	0.00
1949 IV	0.00	0.00	0.00	0.00
1950 I	0.00	0.00	0.00	0.00
1951 I	0.00	0.00	0.00	0.00
1953 III	0.00	0.00	0.00	0.00
1958 III	0.00	0.00	0.00	0.00
1959 III	1.00	1.00	1.00	1.00
1960 II	1.00	1.00	1.00	1.00

Comet's Designation			T_{osc}	T	ω	Ω	i	q	e
definitive	prelim-inary	nominal							
					°	°	°		
1844 II	1844a	Mauvais-d'Arrest	1844 Oct. 17.86279	1844 Oct. 17.84287	211.2609	33.1243	131.4115	0.855388	0.999598
1850 I	1850a	Petersen	1850 May 12.5	1850 July 24.02796	180.5408	94.2819	68.1877	1.081449	0.998852
1853 III	1853e	Klinkerfues	1853 Sep. 2.46279	1853 Sep. 2.20688	170.4375	141.8696	61.5059	0.306839	1.000246
1863 I	1862d	Bruhns	1863 Feb. 2.46279	1863 Feb. 3.99034	74.4604	118.1105	85.3588	0.794763	1.000047
1863 VI	1863c	Baecker-Tempel	1863 Oct. 24.46279	1863 Dec. 29.66656	78.1092	106.2365	83.3173	1.313120	1.000650
1864 III	1864b	Donati-Toussaint	1864 Oct. 14.46279	1864 Oct. 11.89205	232.4550	32.9662	109.7072	0.931212	0.999358
1873 V	1873d	Henry	1873 Oct. 2.46279	1873 Oct. 2.26718	233.7547	177.7976	121.4690	0.384913	0.999730
1874 III	1874c	Coggia	1874 July 16.46279	1874 July 9.35833	152.3745	119.7988	66.3476	0.675738	0.998820
1880 II	1880b	Schaeberle	1880 Apr. 13.46279	1880 July 2.20197	145.1738	258.2294	123.0575	1.814416	1.000841
1882 I	1882b	Wells	[1])	1882 June 11.02963	208.9889	205.8916	73.8033	0.060763	0.999995
1882 II	1882d	Brilliant Comet	1882 Sep. 20.96279	1882 Sep. 17.72403	68.5872	346.9597	142.0046	0.007751	0.999908
1886 I	1885f	Fabry	1885 Dec. 3.46279	1886 Apr. 6.45561	126.5831	37.2640	82.6243	0.642384	1.000446
1886 II	1885g	Barnard	1885 Dec. 10.96279	1886 May 3.78683	119.6161	69.2121	84.4368	0.479270	1.000229
1886 III	1886b	Brooks	[2])	1886 May 5.02030	38.7340	288.7905	100.1680	0.842793	1.012893
1886 IX	1886f	Barnard-Hartwig--Pechüle	1886 Dec. 18.46279	1886 Dec. 16.99670	86.3435	138.2707	101.6194	0.663324	1.000382
1889 I	1888e	Barnard-Brooks	1889 Feb. 5.5	1889 Jan. 31.66858	340.4619	358.2742	166.3777	1.814918	1.001255
1889 II	1889b	Barnard	1889 June 10.46279	1889 June 11.30507	236.0740	311.5370	163.8469	2.255561	0.999675
1889 IV	1889e	Davidson	1889 Aug. 4.46279	1889 July 19.78576	345.8705	287.0100	65.9895	1.039728	0.997720
1890 II	1890a	Brooks	1890 Mar. 17.46279	1890 June 2.03303	68.9294	321.1804	120.5626	1.907583	1.000410
1890 III	1890b	Coggia	1890 July 30.46279	1890 July 9.05209	85.6930	15.1356	63.3312	0.764416	1.001895

General Catalogue of Original and Future Comet Orbits. Part A (continued)

Comet's Designation			T_{osc}	T	ω	Ω	i	q	e
definitive	prelim-inary	nominal							
					°	°	°		
1892 I	1892a	Swift	1892 Mar. 21.46279	1892 Apr. 7.15224	24.5073	241.7251	38.7025	1.026848	0.998782
1892 II	1892b	Denning	1892 May 5.46279	1892 May 11.72472	129.3235	254.2406	89.6970	1.970696	1.000345
1893 I	1892i	Brooks	1893 Jan. 10.46279	1893 Jan. 6.99126	85.2156	186.4483	143.8506	1.195186	1.001586
1893 II	1893a,c	Rordame-Quénisset	1893 July 20.99351	1893 July 7.77146	47.1232	338.1405	159.9742	0.674549	0.999462
1896 I	1896a	Perrine-Lamp	1896 Mar. 15.46279	1896 Feb. 1.28864	358.3606	209.6001	155.7422	0.587353	1.000647
1897 I	1896f	Perrine	1897 Jan. 29.46279	1897 Feb. 8.60357	172.3290	147.2255	146.1370	1.062782	1.000937
1898 I	1898b	Perrine	1898 Mar. 31.5	1898 Mar. 17.63078	47.3128	263.1668	72.5296	1.095245	0.980385
1898 VII	1898d	Coddington-Pauly	1898 June 21.5	1898 Sep. 14.54421	233.2620	74.7119	69.9345	1.701605	1.001034
1898 VIII	1898j	Chase	1898 Dec. 10.5	1898 Sep. 20.62384	4.6306	96.5605	22.5055	2.284667	0.999355
1898 X	1898i	Brooks	1898 Nov. 5.46279	1898 Nov. 23.65791	123.5503	97.0375	140.3478	0.755969	0.999742
1899 I	1899a	Swift	1899 Mar. 12.5	1899 Apr. 13.47801	8.7023	25.7031	146.2640	0.326572	1.000350
1900 II	1900b	Borrelly-Brooks	1900 Aug. 3.49350	1900 Aug. 3.70031	12.4255	328.7136	62.5284	1.014835	1.000416
1901 I	1901a	Viscara	1901 Apr. 28.5	1901 Apr. 24.74991	203.0300	110.3358	131.0836	0.244787	0.999787
1902 III	1902b	Perrine-Borrelly	1902 Nov. 24.35672	1902 Nov. 24.35672	152.9705	50.0299	156.3511	0.401074	0.999968
1903 I	1903a	Giacobini	1903 Feb. 18.49350	1903 Mar. 16.50575	133.7091	2.9522	30.9351	0.410562	0.999666
1904 I	1904a	Brooks	1904 May 3.46279	1904 Mar. 7.63875	53.5348	276.4285	125.1297	2.707778	1.001365
1904 II	1904d	Giacobini	1905 Feb. 28.46279	1904 Nov. 3.77545	40.7384	219.0890	99.6043	1.881833	1.000280
1905 IV	1906b	Kopff	1905 Sep. 11.96279	1905 Oct. 18.25027	158.6167	342.9053	4.2758	3.339887	1.001481
1905 V	1905b	Schaer	[3])	1905 Oct. 26.26648	132.7048	233.5558	140.5817	1.052217	1.000189
1905 VI	1906a	Brooks	1906 Feb. 12.46279	1905 Dec. 22.79708	89.8579	287.0121	126.4402	1.296302	1.000185

General Catalogue of Original and Future Comet Orbits. Part A (continued)

Comet's Designation			T_{osc}	T	ω	Ω	i	q	e
definitive	prelim- inary	nominal							
					°	°	°		
1907 I	1907a	Giacobini	1907 Mar. 19.46279	1907 Mar. 19.60647	317.1080	97.7778	141.6613	2.051674	1.001024
1908 III	1908c	Morehouse	1908 Dec. 28.5	1908 Dec. 26.25609	171.5851	103.7540	140.1771	0.945300	1.000692
1910 I	1910a	Daylight Comet	1910 Jan. 18.5	1910 Jan. 17.58815	320.9024	89.3295	138.7817	0.128975	0.999995
1910 III	1910b	Metcalf	1910 Sep. 16.0	1910 Sep. 16.78129	50.9648	290.0855	121.0527	1.948009	0.999812
1911 IV	1911g	Beljawsky	1911 Oct. 24.46279	1911 Oct. 10.76400	71.7066	89.1985	96.4646	0.303424	1.000170
1912 II	1912a	Gale	1912 Sep. 16.0	1912 Oct. 5.45828	25.6280	297.5344	79.8083	0.716114	0.999514
1914 III	1914c	Neujmin	1914 Aug. 30.96279	1914 July 30.62062	14.0319	270.8117	71.0390	3.747131	1.003672
1914 V	1913f	Delavan	1914 Oct. 28.46279	1914 Oct. 26.76650	97.4612	59.7002	68.0356	1.104454	1.000162
1915 II	1915a	Mellish	1915 Feb. 10.46279	1915 July 17.65148	247.7737	72.7589	54.7904	1.005338	1.000235
1917 III	1916b	Wolf	1917 Mar. 6.5	1917 June 17.06938	120.6210	183.7579	25.6654	1.686453	0.999495
1919 V	1919c	Metcalf-Borrelly	1919 Sep. 19.0	1919 Dec. 7.80965	185.7476	121.4041	46.3860	1.115272	1.000215
1922 II	1922c	Baade	1923 Feb. 17.5	1922 Oct. 26.53015	118.3039	220.8755	51.4614	2.258769	1.000865
1924 I	1924a	Reid	[4]	1924 Mar. 13.99153	271.4581	114.3803	72.3246	1.756083	0.999573
1925 I	1925c	Orkisz	1925 Oct. 25.0	1925 Apr. 1.51116	36.1925	318.4103	100.0185	1.109595	1.000629
1925 VI	1925a	Shain-Comas Solá	1925 Mar. 1.0	1925 Sep. 6.97854	205.7623	357.8391	146.7030	4.180690	1.001941
1925 VII	1925j	van Biesbroeck	1925 Dec. 29.0	1925 Oct. 2.97348	106.4019	334.9121	49.3242	1.566230	1.000428
1927 IV	1927d	Stearns	1927 May 23.0	1927 Mar. 22.72349	11.1353	214.9520	87.6580	3.683732	0.998065
1930 IV	1930b	Beyer	1930 Sep. 24.0	1930 Apr. 18.12119	24.6237	116.6710	71.9737	2.078673	1.000379
1932 VI	1932g	Geddes	1932 Oct. 23.0	1932 Sep. 21.07466	329.6995	215.3981	124.9941	2.313566	1.001376
1936 I	1935d	van Biesbroeck	1936 May 2.0	1936 May 11.63398	44.9007	299.8609	66.1083	4.04335	1.00197

Comet's Designation			T_{osc}	T	ω	Ω	i	q	e
definitive	prelim-inary	nominal							
					°	°	°		
1937 IV	1937b	Whipple	1937 June 19.0	1937 June 20.06136	107.7270	127.9148	41.5559	1.733795	1.000160
1941 VIII	1941d	van Gent	1941 Sep. 13.0 E	1941 Sep. 3.18426 E	85.3286	256.8624	94.5188	0.874789	1.000244
1942 IV	1942a	Whipple-Bernasconi--Kulin	1942 May 1.0	1942 Apr. 30.83332	223.4174	340.2358	79.4457	1.445303	1.000893
1944 I	1943f	van Gent-Peltier--Daimaca	1944 Jan. 11.0 E	1944 Jan. 12.18422 E	32.9722	57.9098	136.1953	0.874700	1.002645
1944 IV	1944d	van Gent	1944 Dec. 16.0	1944 July 17.61350	336.9778	202.8027	95.0164	2.225936	1.002085
1946 I	1946a	Timmers	1946 Mar. 31.0 E	1946 Apr. 13.26405 E	54.3235	128.9679	72.8474	1.724132	1.001177
1946 VI	1946h	Jones	1946 Dec. 16.0 E	1946 Oct. 26.76997 E	320.4217	237.6345	56.9684	1.136222	1.000794
1948 I	1947k	Bester	1948 Feb. 9.0 E	1948 Feb. 16.42288 E	350.2173	270.7402	140.5705	0.748136	1.000307
1948 XI	1948l	Eclipse Comet	1948 Nov. 25.0 E	1948 Oct. 27.42712 E	107.2618	210.3318	23.1222	0.135420	0.999935
1949 I	1948h	Wirtanen	1949 May 14.0	1949 May 1.10909	229.9435	119.9003	130.2714	2.517208	0.999323
1949 IV	1949c	Bappu-Bok-Newkirk	1949 Aug. 2.0 E	1949 Oct. 26.54189 E	89.5315	309.0127	105.7641	2.058202	0.998665
1950 I	1949a	Johnson	1949 Oct. 11.0 E	1950 Jan. 19.31702 E	40.0965	221.6317	131.3537	2.553251	1.000682
1951 I	1950b	Minkowski	1951 Jan. 14.0	1951 Jan. 15.04557	192.4615	38.1856	144.1501	2.572335	1.001212
1953 III	1953a	Mrkos-Honda	1953 May 23.0 E	1953 May 26.43588 E	85.7466	275.1874	93.8561	1.022135	0.997396
1954 V	1955b	Abell	1955 Oct. 20.0 E	1954 Mar. 24.00978 E	73.7692	320.6476	123.9259	4.496796	1.001517
1955 IV	1955f	Bakharev-Macfarlane--Krienke	1955 Sep. 10.0	1955 July 11.54210	13.2237	302.7629	50.0289	1.427445	0.994123
1957 III	1956h	Arend-Roland	5)	1957 Apr. 8.03117	308.7808	215.1591	119.9495	0.316062	1.000230
1957 V	1957d	Mrkos	1957 Aug. 30.0 E	1957 Aug. 1.43750 E	40.3122	67.6249	93.9397	0.354924	0.999351
1958 III	1958a	Burnham	1958 Apr. 27.0 E	1958 Apr. 16.30359 E	16.4562	150.5055	15.7938	1.322686	0.999895
1959 III	1959d	Bester-Hoffmeister	1959 Aug. 20.0 E	1959 July 17.5587 E	186.4830	105.0629	12.8417	1.250541	1.002656
1960 II	1959k	Burnham	1960 Apr. 16.0 E	1960 Mar. 20.99635 E	306.6491	251.9605	159.6018	0.504410	1.000288

Comet	$\left(\frac{1}{a}\right)_{osc}$	P	Perturbing planets	v_1	v_2	int v	int obs.	N	ε	Reference
				°	°	°			″	
1844 II	+0.000470 ± 0.000015	98100	V E J S	−96	+107	203	246	598	±1.63	Ross (1905)
1850 I	+0.001062 [6])	28900	Me V E M J S	−74	+74	148	166	400	±2.04	Carrington (1854)
1853 III	−0.000803 ± 0.000016		Me V E M J S U N	−132	+139	271	213	497	±9.00	Büttner (1918, 1922)
1863 I	−0.000059 ± 0.000060		V E M J S	−83	+59	142	102	119	±3.12	von Flotow (1902)
1863 VI	−0.000495 ± 0.000050		V E M J S	−61	+72	133	185	187	±4.49	Rosén (1867)
1864 III	+0.000689 ± 0.000056	55300	V E J S	−82	+102	184	216	57	±4.32	Schroeter (1905)
1873 V	+0.000701 ± 0.000185	53900	E J S	−105	+123	228	116	124	±9.60	Kreutz (1894)
1874 III	+0.001746 [7])	13700	Me V E M J S	−101	+104	205	174	638	±1.81	von Hepperger (1882)
1880 II	−0.000463 ± 0.000392		E M J S	−44	+38	82	158	156	±1,26	Polak (1913, 1925)
1882 I	+0.000090 ± 0.000020	1170000	[8])	−160	+158	318	150	1000	±4.99	von Rebeur-Paschwitz (1887)
1882 II	+0.011895 ± 0.000271	771	J S	−166	+175	341	261	1252	±1.53	Kreutz (1888)
1886 I	−0.000694 ± 0.000022		Me V E M J S U N	−115	+114	229	242	963	±2.02	Redlich (1911)
1886 II	−0.000478 ± 0.000009		V E J	−130	+117	247	236	761	±1.55	Thraen (1893)
1886 III	−0.015298 ± 0.001871		[2])	−5	+46	51	32	88	±5.50	Kobold (1909)
1886 IX	−0.000576 ± 0.000028		V E J S	−98	+124	222	255	362		Buschbaum (1889)
1889 I	−0.000692 ± 0.000061		V E M J S U N	−66	+115	181	735	1060	±2.05	van Biesbroeck (1940b)
1889 II	+0.000144 ± 0.000042	579000	J S	−28	+97	125	525	126	±1.45	Zweck (1926)
1889 IV	+0.002193 [9])	9740	E J	+3	+93	90	122	400	±2.02	Horn (1904)
1890 II	−0.000215 ± 0.000010		E M J S	−36	+115	151	686	899	±10.85	Strömgren (1896)
1890 III	−0.002478 ± 0.001398		Me V E J S	+22	+61	39	25	63	±1.64	Ogura, Kaneko (1914)

Comet	$\left(\frac{1}{a}\right)_{osc}$	P	Perturbing planets	v_1	v_2	int v	int obs.	N	ε	Reference
				°	°	°			″	
1892 I	+0.001186 ± 0.000012	24500	J	−39	+122	161	347	1124	±7.76	Kühne (1914)
1892 II	−0.000175 ± 0.000033		Me V E J S	−26	+82	108	299	186	±2.93	Steiner (1898)
1893 I	−0.001327 ± 0.000617		V E M J S	−46	+57	103	112	271	±2.02	Polak (1911, 1926)
1893 II	+0.000797 [10])	44400	V E M J S	−42	+121	163	184	286	±2.03	Kromm (1895)
1896 I	−0.001101 ± 0.000639		M J S	+40	+104	64	62	406		Hristoff (1926)
1897 I	−0.000882 ± 0.000048		J S	−82	+77	159	179	152	±3.47	Möller (1901, 1906)
1898 I	+0.017909 ± 0.000064	417	Me V E M J S	+3	+112	109	241	662	±1.60	Curtis (1902)
1898 VII	−0.000607 ± 0.000010		V E M J S	−52	+112	164	544	414	±2.18	Merfield (1901)
1898 VIII	+0.000282 ± 0.000081	211000	J S	+30	+72	42	158	117	±0.88	Wasnetzoff (1914)
1898 X	+0.000341 ± 0.000344	159000	V E J	−55	−1	54	30	266	±3.0	Scharbe (1903)
1899 I	−0.001073 ± 0.000018		V E M J S	−113	+137	250	159	532	±1.91	Merfield (1902a, 1902b)
1900 II	−0.000409 ± 0.000105		V E M J S	−14	+79	93	96	345	±0.96	de Mello e Simas (1903)
1901 I	+0.000868 ± 0.000766	39100	Me V E M J S	+66	+129	63	44	152	±1.04	Merfield (1903)
1902 III	+0.000081 ± 0.000018	1400000	Me E J S	−124	+132	256	212	1182	±2.57	Peck, Lindsey (1911)
1903 I	+0.000814 [11])	43100	V E J S	−114	+108	222	109	507	[11])	Bruck (1907, 1908)
1904 I	−0.000504 ± 0.000008		Me V E M J S U N	+12	+87	75	415	1235	±0.44	Kasakov (1926)
1904 II	−0.000149 ± 0.000040		[12])	+23	+72	49	136	118	±0.24	Sedláček (1910)
1905 IV	−0.000443 ± 0.000008		J S	−89	+87	176	1270	395	±1.70	Pels (1960)
1905 V	−0.000180 ± 0.000151		[3])	+28	+66	38	43	195	±0.98	Zappa (1906a, 1906b)
1905 VI	−0.000142 ± 0.000050		V E M J S U N	+31	+79	48	88	245	±1.05	Mikhailov (1924)

General Catalogue of Original and Future Comet Orbits. Part B (continued)

Comet	$\left(\frac{1}{a}\right)_{osc}$	P	Perturbing planets	v_1	v_2	int v	int obs.	N	ε	Reference
				°	°	°			″	
1907 I	−0.000499 ± 0.000040		E M J S	−4	+92	96	354	175	±1.93	Dubrowsky, Numerow (1913)
1908 III	−0.000732 ± 0.000079		Me V E M J S U N	−95	+101	196	249	1399	±18.50	van Biesbroeck (1943)
1910 I	+0.000040 ± 0.000100	3950000	Me V E M J S	−103	+110	213	180	372	±4.5	de Mello e Simas (1912)
1910 III	+0.000096 ± 0.000005	1060000	J	−19	+88	107	317	656	±1.25	Viaro (1936, 1938)
1911 IV	−0.000561 ± 0.000096		V E J S	−74	+140	214	141	128	±5.33	Grubissich (1951, 1953)
1912 II	+0.000678 [13])	56600	V E J S	−53	+127	180	260	976	±3.97	Peisino, de Caro (1931)
1914 III	−0.000980 ± 0.000079		J	−7	+27	34	182	51	±5.20	Svärdson (1917)
1914 V	−0.000146 ± 0.000003		Me V E M J S	−119	+119	238	629	912	±1.5	van Biesbroeck (1927)
1915 II	−0.000234 ± 0.000061		E J	−103	+110	213	357	170	±16.22	Rosenbaum (1917)
1917 III	+0.000299 ± 0.000006	193000	Me V E J S	−110	+88	198	666	533		du Pui (1932, 1933)
1919 V	−0.000193 ± 0.000056		V E J S	−82	+57	139	166	270	±3.38	Przybylski (1939)
1922 II	−0.000383 ± 0.000018		J	−3	+98	101	466	490	±0.84	Gennaro (1936a, 1936b)
1924 I	+0.000243 [14])	264000	[4])	+9	+82	73	192	112	±3.76	Campa (1931)
1925 I	−0.000566 ± 0.000031		Me V E M J S	+5	+125	120	402	565	±5.70	Orkisz (1933)
1925 VI	−0.000464 ± 0.000018		Me V E M J S	−25	+69	94	713	215	±1.60	Sakk, Kulikov (1951)
1925 VII	−0.000273 ± 0.000023		J S	+20	+96	76	221	320	±0.79	van Biesbroeck (1932)
1927 IV	+0.000525 ± 0.000002	83100	J S U	−3	+110	113	1423	361	±4.87	Shen, Imai (1934)
1930 IV	−0.000182 ± 0.000013		V E J S U N	−68	+104	172	673	249	±2.25	Pels (1947)
1932 VI	−0.000595 ± 0.000001		E M J S U N	−92	+109	201	1070	303	±0.80	van Biesbroeck (1937)
1936 I	−0.000487 ± 0.000215		V E M J S U N	−48	+25	73	830	125	±2.52	van Biesbroeck (1940a)

General Catalogue of Original and Future Comet Orbits. Part B (continued)

Comet	$\left(\frac{1}{a}\right)_{osc}$	P	Perturbing planets	v_1	v_2	int v	int obs.	N	ε	Reference
				°	°	°			″	
1937 IV	−0.000092 ± 0.000020		V E M J S	−64	+63	127	263	381		Chiş (1950)
1941 VIII	−0.000279 ± 0.000007		V E M J S	−90	+112	202	259	319	±1.67	Pels (1960)
1942 IV	−0.000618 ± 0.000005		V E J S	−73	+100	173	376	219	±0.48	Iannini (1945)
1944 I	−0.003024 ± 0.000381		V E M J S	−62	+20	82	57	46	±8.98	Marsden, van Biesbroeck (1963)
1944 IV	−0.000937 ± 0.000016		V E M J S U N	−19	+93	122	436	34	±3.74	Przybylski (1956)
1946 I	−0.000683 ± 0.000007		V E M J S	−41	+114	155	552	373	±1.41	Pels (1960)
1946 VI	−0.000699 ± 0.000018		V E M J S	−67	+135	202	417	124	±2.63	Pels (1960)
1948 I	−0.000410 ± 0.000009		V E M J S U N	−113	+134	247	497	243	±1.94	van Biesbroeck (1961)
1948 XI	+0.000481 ± 0.000032	94800	V E J S	+74	+143	69	146	147		Hirst (1954)
1949 I	+0.000269 ± 0.000008	227000	V E M J S	−73	+84	157	669	69	±2.32	Wierzbiński (1961, 1962)
1949 IV	+0.000649 ± 0.000007	60500	V E J S	−25	+35	60	320	83	±1.99	Belous (1964)
1950 I	−0.000267 ± 0.000018		V E M J S U N	−65	+103	168	650	74	±1.4	Galibina, Barteneva (1965)
1951 I	−0.000471 ± 0.000004		Me V E M J S U N P	−63	+107	170	968	210	±0.52	van Houten--Groeneveld (1963a)
1953 III	+0.002547 ± 0.000023	7780	V E M J S	−52	+114	166	263	46	±2.1[15]	Marsden (1963a)
1954 V	−0.000337 ± 0.000018		V E M J S U N	+49	+78	29	382	34	±0.86	van Biesbroeck, Marsden (1963a)
1955 IV	+0.004117 ± 0.000046	3790	Me V E M J S U N P	+3	+78	75	133	193	±0.84	vanHouten--Groeneveld (1963a)
1957 III	−0.000727 [16]		[5]	−140	+131	271	222	116	[16]	Hasegawa (1957)
1957 V	+0.001830 ± 0.000017	12800	V E J S	+20	+153	133	339	225	±7.70	Schrutka-Rechtenstamm (1960a, 1960b)
1958 III	+0.000079 ± 0.000014	1420000	V E M J S U N	−50	+89	139	211	121	±0.4[15]	Marsden (1963b)
1959 III	−0.002124 ± 0.000254[17]		E J S	−41	+49	90	102	29	±1.25	Schubart (1961)
1960 II	−0.000570 ± 0.000022		V E M J S	−114	+116	230	170	182	±2.18	van Biesbroeck, Marsden (1963b)

Comet	P_x	P_y	P_z	Q_x	Q_y	Q_z	R_x	R_y	R_z
1844 II	−0.903470	−0.009962	−0.428536	+0.125621	+0.949682	−0.286920	+0.409831	−0.313056	−0.856758
1850 I	+0.078158	−0.911109	−0.404688	+0.369809	+0.403465	−0.836933	+0.925815	−0.084244	+0.368470
1853 III	+0.726743	−0.673887	−0.133117	+0.421148	+0.590219	−0.688676	+0.542659	+0.444429	+0.712744
1863 I	−0.195096	−0.199080	+0.960367	+0.435280	−0.895042	−0.097113	+0.878902	+0.399082	+0.261274
1863 VI	−0.166943	−0.234413	+0.957695	+0.250582	−0.949521	−0.188731	+0.953593	+0.208473	+0.217256
1864 III	−0.656755	+0.198576	−0.727489	+0.553398	+0.782251	−0.286067	+0.512273	−0.590467	−0.623639
1873 V	+0.574627	−0.133126	−0.807515	−0.817759	−0.053879	−0.573034	+0.032778	+0.989634	−0.139825
1874 III	+0.278872	−0.959178	+0.046978	+0.538885	+0.115810	−0.834381	+0.794879	+0.258001	+0.549183
1880 II	−0.137511	+0.605135	+0.784157	+0.554861	+0.702863	−0.445098	−0.820500	+0.373892	−0.432417
1882 I	+0.727881	+0.647174	−0.226616	−0.542535	+0.341439	−0.767512	−0.419338	+0.681605	+0.599642
1882 II	+0.190129	−0.959336	+0.208630	−0.971883	−0.153851	+0.178248	−0.138901	−0.236654	−0.961614
1886 I	−0.536736	−0.572656	+0.619661	−0.592740	−0.266754	−0.759936	+0.600478	−0.775182	−0.196259
1886 II	−0.254183	−0.740699	+0.621897	−0.263753	−0.565556	−0.781397	+0.930497	−0.362646	−0.051607
1886 III	+0.146692	−0.955201	+0.257044	−0.331914	+0.197259	+0.922454	−0.931834	−0.220633	−0.288108
1886 IX	+0.086193	−0.212369	+0.973381	+0.753328	−0.625474	−0.203171	+0.651972	+0.750787	+0.106072
1889 I	+0.951780	+0.303356	+0.045707	+0.306698	−0.937461	−0.164632	−0.007093	+0.170711	−0.985296
1889 II	+0.226485	+0.959986	+0.164717	+0.951493	−0.181906	−0.248136	−0.208244	+0.212926	−0.954619
1889 IV	+0.188703	−0.788696	−0.585107	+0.448745	−0.460716	+0.765747	−0.873510	−0.407062	+0.266985
1890 II	−0.017329	−0.865620	+0.500402	−0.841627	+0.282818	+0.460086	−0.539782	−0.413179	−0.733430
1890 III	−0.044366	+0.059810	+0.997223	−0.971386	−0.235721	−0.029079	+0.233327	−0.969979	+0.068556

General Catalogue of Original and Future Comet Orbits. Part C (continued)

Comet	P_x	P_y	P_z	Q_x	Q_y	Q_z	R_x	R_y	R_z
1892 I	−0.145932	−0.979065	−0.141897	+0.821866	−0.199820	+0.533486	−0.550672	−0.038767	+0.833821
1892 II	+0.176049	+0.250716	+0.951918	+0.206878	+0.936002	−0.284785	−0.962397	+0.247067	+0.112914
1893 I	−0.173248	+0.491079	+0.853713	+0.982647	+0.144497	+0.116295	−0.066249	+0.859047	−0.507591
1893 II	+0.375147	−0.918523	−0.124820	−0.918155	−0.386718	+0.086261	−0.127503	+0.082244	−0.988423
1896 I	−0.856255	−0.469106	−0.216257	−0.475022	+0.550611	+0.686426	−0.202933	+0.690483	−0.694300
1897 I	+0.893286	−0.436287	−0.108140	−0.333251	−0.481382	−0.810688	+0.301636	+0.760214	−0.575405
1898 I	+0.138441	−0.920666	+0.364977	+0.289555	+0.390050	+0.874082	−0.947097	−0.015328	+0.320582
1898 VII	+0.107501	−0.296363	−0.949006	+0.409263	+0.883102	−0.229421	+0.906061	−0.363731	+0.216225
1898 VIII	−0.187974	+0.888341	+0.418945	−0.905574	−0.321902	+0.276252	+0.380266	−0.327458	+0.864968
1898 X	+0.704540	−0.642693	+0.300946	−0.320204	−0.666341	−0.673394	+0.633318	+0.378069	−0.675257
1899 I	+0.945251	+0.255874	+0.202559	+0.220192	−0.958169	+0.182831	+0.240867	−0.128220	−0.962051
1900 II	+0.886112	−0.463416	+0.007110	+0.050073	+0.110975	+0.992561	−0.460758	−0.879164	+0.121541
1901 I	+0.078759	−0.756334	−0.649427	−0.703044	+0.419721	−0.574076	+0.706772	+0.501789	−0.498679
1902 III	−0.253189	−0.944176	−0.210779	−0.917273	+0.303534	−0.257834	+0.307419	+0.128061	−0.942918
1903 I	−0.722014	+0.387583	+0.573128	−0.691372	−0.435867	−0.576216	+0.026476	−0.812281	+0.582666
1904 I	−0.393317	−0.851070	+0.347824	−0.429890	+0.504649	+0.748681	−0.812709	+0.144943	−0.564354
1904 II	−0.656753	−0.616791	+0.433871	+0.426823	+0.170284	+0.888159	−0.621689	+0.768487	+0.151426
1905 IV	−0.783145	+0.559136	+0.272121	−0.621452	−0.688317	−0.374188	−0.021916	−0.462154	+0.886529
1905 V	+0.100329	+0.620539	+0.777731	+0.893585	+0.287548	−0.344705	−0.437538	+0.729553	−0.525655
1905 VI	−0.567265	−0.481696	+0.667966	−0.293981	+0.876101	+0.382129	−0.769276	+0.020399	−0.638591

General Catalogue of Original and Future Comet Orbits. Part C (continued)

Comet	P_x	P_y	P_z	Q_x	Q_y	Q_z	R_x	R_y	R_z
1907 I	−0.628086	+0.767667	−0.127261	+0.477254	+0.509206	+0.716197	+0.614602	+0.389098	−0.686197
1908 III	+0.344365	−0.894309	−0.285698	−0.703181	−0.044063	−0.709645	+0.622053	+0.445274	−0.644035
1910 I	−0.465259	+0.882381	−0.070268	+0.591105	+0.368801	+0.717342	+0.658885	+0.292214	−0.693168
1910 III	−0.160018	−0.933666	+0.320410	−0.571864	+0.352257	+0.740868	−0.804590	−0.064679	−0.590298
1911 IV	+0.111279	−0.088803	+0.989814	+0.022055	−0.995534	−0.091796	+0.993544	+0.032045	−0.108824
1912 II	+0.484666	−0.870409	+0.086526	−0.058484	+0.066453	+0.996074	−0.872742	−0.487824	−0.018697
1914 III	+0.092518	−0.980185	−0.175152	+0.311763	−0.138546	+0.940005	−0.945645	−0.141573	+0.292767
1914 V	−0.385717	−0.297075	+0.873481	−0.458318	−0.759971	−0.460857	+0.800729	−0.578092	+0.156979
1915 II	+0.397630	−0.175641	−0.900578	+0.482667	+0.874772	+0.042503	+0.780335	−0.451580	+0.432612
1917 III	+0.559098	−0.827752	+0.047275	+0.828615	+0.559814	+0.002321	−0.028387	+0.037875	+0.998879
1919 V	+0.577412	−0.717235	−0.390088	+0.533607	+0.693137	−0.484586	+0.617947	+0.071652	+0.782948
1922 II	+0.717503	−0.369873	+0.590241	+0.472410	+0.881101	−0.022126	−0.511878	+0.294711	+0.806924
1924 I	+0.265955	+0.515187	−0.814770	−0.419695	+0.822782	+0.383257	+0.867827	+0.240026	+0.435044
1925 I	+0.535408	−0.793330	+0.289769	−0.534840	−0.052938	+0.843294	−0.653670	−0.606486	−0.452648
1925 VI	−0.886266	+0.459147	−0.060954	+0.462713	+0.871799	−0.160818	−0.020700	−0.170732	−0.985100
1925 VII	+0.009379	+0.339880	+0.940422	−0.946839	+0.305458	−0.100953	−0.321572	−0.889481	+0.324677
1927 IV	−0.799681	−0.598407	−0.049191	+0.181263	−0.318709	+0.930359	−0.572411	+0.735074	+0.363334
1930 IV	−0.523266	+0.534530	+0.663680	−0.064358	−0.801376	+0.594689	+0.849736	+0.268468	+0.453733
1932 VI	−0.536185	−0.510766	−0.672030	−0.698087	−0.179251	+0.693213	−0.474531	+0.840825	−0.260447
1936 I	+0.600608	−0.689773	+0.404330	−0.102662	+0.434984	+0.894566	−0.792925	−0.578793	+0.190442

General Catalogue of Original and Future Comet Orbits. Part C (continued)

Comet	P_x	P_y	P_z	Q_x	Q_y	Q_z	R_x	R_y	R_z
1937 IV	−0.375228	−0.873615	+0.309840	+0.765066	−0.480609	−0.428589	+0.523334	+0.076229	+0.848711
1941 VIII	−0.094980	−0.451714	+0.887093	+0.220287	+0.859492	+0.461245	−0.970800	+0.239224	+0.017872
1942 IV	−0.726148	+0.385487	−0.569306	+0.601831	−0.043978	−0.797412	−0.332429	−0.921665	−0.200064
1944 I	+0.778450	+0.310750	+0.545389	+0.223830	−0.949164	+0.221332	+0.586443	−0.050222	−0.808432
1944 IV	−0.835170	−0.201153	−0.511888	−0.391712	−0.435782	+0.810343	−0.386075	+0.877286	+0.285158
1946 I	−0.553035	−0.031049	+0.832579	+0.377129	−0.900398	+0.216927	+0.742917	+0.433958	+0.509661
1946 VI	−0.705948	−0.214172	−0.675106	+0.013803	−0.957163	+0.289219	−0.708130	+0.194855	+0.678663
1948 I	+0.143961	−0.859528	−0.490394	−0.758917	−0.413923	+0.502706	−0.635075	+0.299799	−0.711899
1948 XI	+0.699640	−0.707168	+0.102064	+0.686423	+0.704906	+0.178695	−0.198313	−0.054963	+0.978596
1949 I	−0.108110	−0.505735	−0.855888	−0.742172	+0.613865	−0.268980	+0.661432	+0.606137	−0.441707
1949 IV	−0.205941	−0.545626	+0.812330	−0.631198	+0.708417	+0.315809	−0.747782	−0.447703	−0.490290
1950 I	−0.854462	−0.366796	+0.367908	+0.145636	+0.510662	+0.847357	−0.498684	+0.777615	−0.382922
1951 I	−0.875622	−0.377398	−0.301423	−0.319680	+0.920655	−0.224054	+0.362064	−0.099828	−0.926792
1953 III	−0.060085	−0.469216	+0.881037	−0.095132	+0.881306	+0.462871	−0.993650	−0.056003	−0.097591
1954 V	−0.123660	−0.859747	+0.495524	−0.841358	+0.355604	+0.407017	−0.526141	−0.366581	−0.767329
1955 IV	+0.650389	−0.747825	−0.133236	+0.402089	+0.190127	+0.895643	−0.644452	−0.636089	+0.424349
1957 III	−0.287962	−0.354056	−0.889788	−0.817388	−0.393234	+0.421004	−0.498953	+0.848535	−0.176165
1957 V	+0.331375	+0.374578	+0.865957	−0.197828	−0.869828	+0.451955	+0.922526	−0.321077	−0.214137
1958 III	−0.968954	+0.184838	+0.164203	−0.207777	−0.968731	−0.135609	+0.134003	−0.165517	+0.977061
1959 III	+0.364519	−0.844018	−0.393394	+0.906125	+0.418867	−0.059053	+0.214622	−0.334938	+0.917472
1960 II	+0.530183	−0.623093	−0.575031	−0.780432	−0.623710	−0.043723	−0.331409	+0.471954	−0.816962

Comet	α_π	δ_π	λ_π	β_π	l_π^{II}	b_π^{II}	α_p	δ_p	λ_p	β_p	l_p^{II}	b_p^{II}
	°	°	°	°	°	°	°	°	°	°	°	°
1844 II	180.63	−25.37	191.25	−22.90	289.99	+36.05	322.63	−58.95	303.12	−41.41	335.92	−43.70
1850 I	274.90	−23.87	274.48	−0.50	8.51	−4.73	354.80	+21.62	4.28	+21.81	102.24	−38.15
1853 III	317.16	−7.65	317.27	+8.40	42.97	−34.39	39.32	+45.46	51.87	+28.49	142.13	−13.09
1863 I	225.58	+73.82	134.37	+73.80	111.39	+40.45	24.42	+15.15	28.14	+4.64	139.99	−45.84
1863 VI	234.54	+73.27	135.16	+76.38	108.55	+39.04	12.33	+12.55	16.24	+6.68	123.11	−50.05
1864 III	163.18	−46.68	189.28	−48.28	283.12	+11.39	310.94	−38.58	302.97	−19.71	3.94	−38.32
1873 V	346.96	−53.85	322.34	−43.46	331.13	−57.69	88.10	−8.04	87.80	−31.47	213.76	−16.22
1874 III	286.21	+2.69	287.94	+25.13	37.21	−2.27	17.98	+33.31	29.80	+23.65	128.47	−29.05
1880 II	102.80	+51.64	99.01	+28.60	164.83	+21.48	155.50	−25.62	168.23	−33.06	266.02	+26.26
1882 I	41.64	−13.10	34.68	−27.74	191.39	−59.06	121.60	+36.84	115.89	+16.20	184.48	+30.75
1882 II	281.21	+12.04	283.42	+34.97	43.26	+6.42	239.59	−74.07	256.96	−52.00	315.12	−16.11
1886 I	226.85	+38.29	207.45	+52.78	62.57	+59.17	307.76	−11.32	307.26	+7.38	34.40	−27.68
1886 II	251.06	+38.49	239.53	+59.91	61.61	+40.26	338.71	−2.96	339.21	+5.56	64.44	−49.71
1886 III	278.73	+14.89	280.73	+38.02	44.77	+9.84	193.32	−16.74	198.79	−10.17	304.47	+45.84
1886 IX	292.09	+76.75	65.89	+77.83	108.64	+24.40	49.03	+6.09	48.27	−11.62	175.26	−41.17
1889 I	17.68	+2.62	17.30	−4.52	133.73	−59.53	92.38	−80.16	268.27	−76.38	291.94	−28.65
1889 II	76.73	+9.48	76.54	−13.35	191.99	−17.55	134.36	−72.67	221.54	−73.85	287.67	−17.38
1889 IV	283.46	−35.81	281.16	−12.88	0.75	−16.52	204.99	+15.48	197.01	+24.01	350.37	+73.22
1890 II	268.85	+30.03	268.38	+53.47	55.69	+24.10	217.43	−47.17	231.18	−30.56	320.20	+12.05
1890 III	126.57	+85.73	95.61	+63.01	127.45	+29.09	283.53	+3.93	285.14	+26.67	37.08	+0.68

General Catalogue of Original and Future Comet Orbits. Part D (continued)

Comet	α_π	δ_π	λ_π	β_π	l_π^{II}	b_π^{II}	α_p	δ_p	λ_p	β_p	l_p^{II}	b_p^{II}
	°	°	°	°	°	°	°	°	°	°	°	°
1892 I	261.52	−8.16	261.31	+15.03	15.77	+14.22	184.03	+56.49	151.73	+51.30	132.18	+60.32
1892 II	52.92	+72.16	73.87	+50.68	135.35	+13.77	165.60	+6.48	164.24	+0.30	247.69	+57.18
1893 I	109.43	+58.62	102.37	+36.00	158.36	+26.78	94.41	−30.50	96.45	−53.85	237.92	−19.75
1893 II	292.22	−7.17	292.80	+14.53	31.14	−12.12	147.18	−81.27	248.14	−69.97	296.39	−21.08
1896 I	208.72	−12.49	211.09	−0.67	326.96	+47.03	106.38	−43.97	119.60	−65.74	254.73	−15.87
1897 I	333.97	−6.21	333.61	+4.27	56.13	−47.96	68.36	−35.13	57.23	−56.14	236.92	−42.04
1898 I	298.55	+21.41	281.20	+44.52	50.69	+12.78	180.93	+18.70	173.17	+17.47	250.52	+76.44
1898 VII	289.94	−71.62	279.40	−48.83	323.79	−28.31	338.13	+12.49	344.71	+20.07	78.84	−38.17
1898 VIII	101.95	+24.77	100.84	+1.77	190.60	+10.87	319.27	+59.88	6.56	+67.49	99.17	+7.46
1898 X	317.63	+17.51	326.30	+32.13	66.84	−20.59	30.84	−42.47	7.04	−50.35	262.76	−68.66
1899 I	15.15	+11.69	18.45	+4.82	127.49	−50.81	331.97	−74.16	295.70	−56.26	316.10	−38.87
1900 II	332.39	+0.41	334.52	+11.01	62.29	−42.71	242.34	+6.98	238.71	+27.47	19.33	+38.41
1901 I	275.94	−40.50	274.73	−17.15	353.87	−12.99	35.37	−29.91	20.34	−41.08	225.57	−69.59
1902 III	254.99	−12.17	255.08	+10.50	8.66	+17.49	22.62	−70.55	320.03	−66.35	298.01	−46.44
1903 I	151.77	+34.97	141.05	+21.81	190.35	+54.81	271.87	+35.64	272.95	+59.06	62.38	+23.46
1904 I	245.20	+20.35	238.52	+41.13	36.73	+41.42	169.89	−39.36	186.43	−35.13	282.77	+24.71
1904 II	223.20	+25.71	210.91	+40.05	36.66	+62.33	128.97	+8.71	129.09	−9.60	217.54	+27.60
1905 IV	144.47	+15.79	141.58	+1.56	217.49	+44.38	267.28	+62.44	252.91	+85.72	91.60	+30.94
1905 V	80.82	+51.05	83.49	+27.81	159.31	+8.86	120.95	−31.71	133.56	−50.58	249.31	+0.02
1905 VI	220.34	+41.91	197.25	+53.56	72.70	+62.91	178.48	−39.69	197.01	−36.44	291.63	+21.69

General Catalogue of Original and Future Comet Orbits. Part D (continued)

Comet	α_π	δ_π	λ_π	β_π	l_π^{II}	b_π^{II}	α_p	δ_p	λ_p	β_p	l_p^{II}	b_p^{II}
	°	°	°	°	°	°	°	°	°	°	°	°
1907 I	129.29	−7.31	133.86	−24.97	232.94	+19.98	32.34	−43.33	7.78	−51.66	262.73	−67.26
1908 III	291.06	−16.60	290.24	+5.38	21.88	−15.18	35.60	−40.09	13.75	−50.18	252.34	−66.91
1910 I	117.80	−4.03	120.76	−24.55	223.93	+11.83	23.92	−43.88	359.33	−48.78	276.35	−71.02
1910 III	260.27	+18.69	257.62	+41.72	40.87	+27.53	184.60	−36.18	200.09	−31.05	296.13	+26.00
1911 IV	321.41	+81.82	70.39	+70.63	116.16	+22.07	1.85	−6.25	359.20	−6.46	96.07	−66.66
1912 II	299.11	+4.96	302.39	+25.20	45.41	−12.52	209.20	−1.07	207.53	+10.19	335.54	+57.20
1914 III	275.39	−10.09	275.45	+13.26	20.89	+1.36	188.51	+17.02	180.81	+18.96	283.85	+79.05
1914 V	217.60	+60.87	169.00	+66.86	103.01	+52.42	324.17	+9.03	329.70	+21.96	64.09	−30.90
1915 II	336.17	−64.23	307.43	−49.14	324.87	−46.59	329.94	+25.63	342.76	+35.21	81.70	−23.13
1917 III	304.04	+2.71	307.05	+21.88	45.91	−17.91	126.85	+87.29	93.76	+64.33	125.80	+28.50
1919 V	308.84	−22.96	305.38	−4.16	22.23	−33.05	6.61	+51.53	31.40	+43.61	119.43	−10.91
1922 II	322.73	+36.71	351.71	+43.53	90.63	−16.33	150.07	+53.80	130.88	+38.54	160.60	+49.46
1924 I	62.70	−54.56	29.17	−72.27	264.07	−44.65	15.46	+25.79	24.38	+17.68	126.61	−36.72
1925 I	304.01	+16.84	311.16	+35.56	58.32	−10.47	222.86	−26.91	228.41	−10.02	334.02	+28.23
1925 VI	152.61	−3.49	155.87	−13.80	245.64	+40.87	263.09	−80.10	267.84	−56.70	313.23	−23.78
1925 VII	88.42	+70.12	89.22	+46.68	143.73	+21.14	250.12	+18.95	244.91	+40.68	37.06	+36.58
1927 IV	216.81	−2.82	215.41	+11.13	344.96	+51.62	127.91	+21.31	124.95	+2.34	203.74	+31.70
1930 IV	134.39	+41.58	124.74	+23.34	180.33	+41.20	17.53	+26.98	26.67	+18.03	128.76	−35.38
1932 VI	223.61	−42.22	233.93	−24.41	326.47	+14.61	119.44	−15.10	125.40	−34.99	234.46	+7.67
1936 I	311.05	+23.85	321.84	+40.20	68.03	−11.84	216.13	+10.98	209.86	+23.89	1.45	+62.20

General Catalogue of Original and Future Comet Orbits. Part D (continued)

Comet	α_π	δ_π	λ_π	β_π	l_π^{II}	b_π^{II}	α_p	δ_p	λ_p	β_p	l_p^{II}	b_p^{II}
	°	°	°	°	°	°	°	°	°	°	°	°
1937 IV	246.76	+18.05	241.05	+39.19	34.56	+39.25	8.29	+58.07	37.91	+48.44	120.90	−4.47
1941 VIII	258.13	+62.51	212.91	+83.50	91.99	+35.15	166.16	+1.02	166.86	−4.52	255.12	+53.65
1942 IV	152.04	−34.70	170.07	−42.51	269.25	+17.18	250.17	−11.54	250.24	+10.55	6.33	+21.70
1944 I	21.76	+33.05	32.82	+22.13	132.10	−28.88	355.11	−53.94	327.91	−46.20	323.71	−60.62
1944 IV	193.54	−30.79	204.93	−22.93	304.30	+31.80	113.75	+16.57	112.80	−5.02	203.02	+17.51
1946 I	183.21	+56.36	151.30	+50.91	133.13	+60.33	30.29	+30.64	38.97	+17.15	140.82	−29.45
1946 VI	196.88	−42.46	213.38	−32.29	306.63	+20.01	164.61	+42.74	147.63	+33.03	171.34	+62.86
1948 I	279.51	−29.37	278.33	−6.20	5.43	−10.88	154.73	−45.39	180.74	−50.57	276.74	+9.59
1948 XI	314.69	+5.86	319.00	+22.02	54.82	−25.26	195.49	+78.12	120.33	+66.88	122.14	+39.26
1949 I	257.93	−58.86	262.35	−35.73	331.78	−11.82	42.50	−26.21	29.90	−40.27	217.49	−63.04
1949 IV	249.32	+54.32	220.74	+74.23	82.60	+40.94	210.91	−29.36	219.01	−15.76	321.89	+30.50
1950 I	203.23	+21.59	192.54	+28.91	5.21	+78.45	122.67	−22.51	131.63	−41.35	242.42	+6.32
1951 I	203.32	−17.54	208.03	−7.26	317.69	+43.79	344.58	−67.94	308.19	−54.15	317.59	−46.21
1953 III	262.70	+61.77	233.07	+84.26	90.85	+33.09	183.23	−5.60	185.19	−3.86	286.85	+55.86
1954 V	261.82	+29.70	258.19	+52.82	53.26	+29.82	214.87	−50.11	230.65	−33.93	317.50	+9.93
1955 IV	311.01	−7.66	311.35	+10.10	39.64	−28.99	224.63	+25.11	212.76	+39.97	35.93	+60.95
1957 III	230.88	−62.85	247.01	−42.49	319.63	−5.33	120.46	−10.15	125.16	−29.95	230.68	+11.07
1957 V	48.50	+59.99	64.29	+40.20	140.22	+2.32	340.81	−12.36	337.62	−3.94	53.79	−56.98
1958 III	169.20	+9.45	166.37	+4.42	248.15	+61.81	308.99	+77.70	60.51	+74.21	111.21	+21.38
1959 III	293.36	−23.17	291.39	−1.44	16.47	−19.78	302.65	+66.56	15.06	+77.16	100.00	+17.40
1960 II	310.39	−35.10	303.52	−16.24	8.23	−37.39	125.08	−54.78	161.96	−69.60	270.31	−10.21

Comet	$\left(\frac{1}{a_b}\right)_{orig}$	Perturbing planets	v_{orig} °	r_{orig}	int pert.	Reference	Catalogue Values	
							$\left(\frac{1}{a_b}\right)_{orig}$	$\left(\frac{1}{a_b}\right)_{orig} - \left(\frac{1}{a}\right)_{osc}$
1844 II	+0.001007	V E M J S U N P	−167.3	70.1	44.8	Brady (1965)	+0.001007 ± 0.000015	+0.000537
1850 I	+0.001880	J S U N	−166.2	74.6	49.1	Galibina (1964)	+0.001890[18])	+0.000828
1853 III	+0.000099	V E J S	−169.8	39.0	18.5	Büttner (1918. 1922)	+0.000046 ± 0.000021	+0.000849
	−0.000004	J S U N	−168.8	32.1	13.9	Galibina (1964)		
1863 I	+0.000528	V E J S U N	−160.0	26.3	10.6	Bilo, van Houten-Groeneveld (1960)	+0.000528 ± 0.000060	+0.000587
1863 VI	+0.000012	Me V E M J S	−158.6	38.1	18.4	Rasmusen (1937)	+0.000033 ± 0.000051	+0.000528
	+0.000029	J S U N	−164.7	74.5	49.3	Galibina (1963)		
1864 III	+0.001047	J S U N	−166.2	64.2	39.4	Galibina (1964)	+0.001058 ± 0.000058	+0.000369
1873 V	+0.001333	V E J S U N	−167.2	30.8	13.1	Galibina (1964)	+0.001336 ± 0.000185	+0.000635
1874 III	+0.003203	J S U N	−165.8	43.9	22.4	Galibina (1964)	+0.003216[19])	+0.001470
1880 II	+0.000511	J S U N	−160.0	60.2	36.4	Galibina (1963)	+0.000534 ± 0.000392	+0.000997
	+0.000534	V E M J S U N P	−164.8	103.3	80.3	Brady (1965)		
1882 I	+0.000144	V E J S U N	−174.5	26.0	10.0	Bilo, van Houten-Groeneveld (1960)	+0.000144 ± 0.000020	+0.000054
1882 II	+0.012148	J S	−178.2	32.5	13.9	Strömgren (1914)	+0.012170 ± 0.000272	+0.000275
1886 I	−0.000007	J S	−163.7	32.0	13.6	Strömgren (1914)	−0.000005 ± 0.000022	+0.000689
	+0.000002	J S U N	−165.8	41.8	20.4	Galibina (1964)		
	−0.000005	V E M J S U N P	−171.2	109.1	85.9	Brady (1965)		
1886 II	−0.000005[20])	J S	−157.6	12.7	3.2	Thraen (1894)	+0.000333 ± 0.000009	+0.000811
	+0.000316	J S	−165.7	30.9	12.8	Strömgren (1914)		
	+0.000358	J S U N	−169.6	58.4	33.5	Galibina (1964)		
	+0.000333	V E M J S U N P	−172.4	109.2	85.8	Brady (1965)		

General Catalogue of Original and Future Comet Orbits. Part E (continued)

Comet	$\left(\frac{1}{a_b}\right)_{orig}$	Perturbing planets	v_{orig}	r_{orig}	int pert.	Reference	Catalogue Values	
							$\left(\frac{1}{a_b}\right)_{orig}$	$\left(\frac{1}{a_b}\right)_{orig} - \left(\frac{1}{a}\right)_{osc}$
			°					
1886 III	−0.014666	V E M J S U N P	−169.9	109.0	86.4	Brady (1965)	−0.014666 ± 0.001871	+0.000632
1886 IX	+0.000063	J S	−163.4	31.8	13.9	Strömgren (1914)	+0.000084 ± 0.000028	+0.000660
	+0.000076	J S U N	−165.8	43.1	21.7	Galibina (1964)		
	+0.000084	V E M J S U N P	−171.1	109.7	87.0	Brady (1965)		
1889 I	+0.000042	J S U N	−154.9	38.4	19.1	van Biesbroeck (1940b)	+0.000035 ± 0.000061	+0.000727
	+0.000041	J S U N	−160.0	60.2	36.6	Galibina (1963)		
	+0.000035	V E M J S U N P	−165.3	110.3	89.1	Brady (1965)		
1889 II	+0.000969	J S U N	−160.0	74.8	50.7	Galibina (1963)	+0.000986 ± 0.000042	+0.000842
	+0.000992	J S U N	−143.5	23.0	9.4	van Houten-Groeneveld (1963b)		
1889 IV	+0.002798	V E M J S U N P	−168.9	111.5	89.6	Brady (1965)	+0.002798[21])	+0.000605
1890 II	+0.000072	J S	−152.1	32.6	14.9	Strömgren (1914)	+0.000089 ± 0.000010	+0.000304
	+0.000088	J S U N	−160.0	63.3	39.2	Galibina (1963)		
	+0.000089	V E M J S U N P	−165.0	111.4	90.2	Brady (1965)		
1890 III	−0.002142	V E M J S U N P	−170.5	112.6	90.6	Brady (1965)	−0.002142 ± 0.001398	+0.000336
1892 I	+0.001144	V E J S U N	−157.2	26.3	10.7	van Houten-Groeneveld (1963b)	+0.001141 ± 0.000012	−0.000045
	+0.001144	J S U N	−166.2	70.8	45.6	Galibina (1964)		
	+0.001141	V E M J S U N P	−169.1	113.8	92.2	Brady (1965)		
1892 II	+0.000853	J S U N	−146.3	23.5	9.5	Bilo, van Houten-Groeneveld (1960)	+0.000856 ± 0.000033	+0.001031
	+0.000845	J S U N	−160.0	65.4	41.4	Galibina (1963)		
	+0.000856	V E M J S U N P	−164.8	112.9	92.3	Brady (1965)		
1893 I	−0.000852	J S U N	−164.7	67.8	43.0	Galibina (1963)	−0.000825 ± 0.000617	+0.000502
	−0.000825	V E M J S U N P	−168.3	114.2	93.0	Brady (1965)		
1893 II	+0.000979	J S U N	−165.8	43.9	22.3	Galibina (1964)	+0.000992[22])	+0.000195

General Catalogue of Original and Future Comet Orbits. Part E (continued)

Comet	$\left(\frac{1}{a_b}\right)_{orig}$	Perturbing planets	v_{orig}	r_{orig}	int pert.	Reference	Catalogue Values	
							$\left(\frac{1}{a_b}\right)_{orig}$	$\left(\frac{1}{a_b}\right)_{orig} - \left(\frac{1}{a}\right)_{osc}$
			°					
1896 I	−0.000273	V E M J S U N P	−171.9	117.3	96.2	Brady (1965)	−0.000273 ± 0.000639	+0.000828
1897 I	+0.000027	J S	−158.8	31.5	13.8	Strömgren (1914)	+0.000049 ± 0.000048	+0.000931
	+0.000030	J S	−160.2	36.0	16.9	Strömgren, Rasmusen (1938)		
	+0.000044	J S U N	−166.2	73.3	48.0	Galibina (1964)		
	+0.000049	V E M J S U N P	−169.1	117.7	97.1	Brady (1965)		
1898 I	+0.018536	V E M J S U N P	−169.0	118.6	98.2	Brady (1965)	+0.018536 ± 0.000064	+0.000627
1898 VII	−0.000017	J S	−153.0	31.3	13.9	Strömgren (1914)	+0.000002 ± 0.000010	+0.000609
	−0.000016	J S U N	−160.0	56.4	33.0	Galibina (1958)		
	+0.000002	V E M J S U N P	−166.2	118.4	98.5	Brady (1965)		
1898 VIII	+0.000010	V E J S U N	−146.3	27.2	12.1	Bilo, van Houten-Groeneveld (1960)	−0.000008 ± 0.000081	−0.000290
	−0.000008	V E M J S U N P	−164.0	117.8	98.9	Brady (1965)		
1898 X	+0.001347	V E M J S U N P	−170.9	119.5	98.8	Brady (1965)	+0.001347 ± 0.000344	+0.001006
1899 I	−0.000027	Me V E M J S U N P	−170.8	50.8	27.3	Rasmusen (1952)	−0.000109 ± 0.000018	+0.000964
	−0.000123	J S U N	−169.3	37.9	17.6	Galibina (1963)		
	−0.000110	V E J S U N	−169.3	37.9	17.6	Galibina (1964)		
	−0.000109	V E M J S U N P	−174.0	120.2	99.2	Brady (1965)		
1900 II	+0.000610	V E M J S U N P	−169.5	120.6	100.6	Brady (1965)	+0.000610 ± 0.000105	+0.001019
1901 I	+0.001078	V E M J S U N P	−174.9	121.9	101.3	Brady (1965)	+0.001078 ± 0.000766	+0.000210
1902 III	−0.000017	J S	−167.2	32.2	13.9	Strömgren (1914)	+0.000027 ± 0.000018	−0.000054
	+0.000005	J S	−168.3	38.7	18.3	Strömgren, Rasmusen (1938)		
	+0.000017	J S U N	−170.3	56.0	31.8	Galibina (1964)		
	+0.000027	V E M J S U N P	−173.5	123.0	102.9	Brady (1965)		
1903 I	+0.001054	J S U N	−167.2	32.9	14.3	Galibina (1964)	+0.001067[23])	+0.000253

General Catalogue of Original and Future Comet Orbits. Part E (continued)

Comet	$\left(\frac{1}{a_b}\right)_{orig}$	Perturbing planets	v_{orig}	r_{orig}	int pert.	Reference	Catalogue Values $\left(\frac{1}{a_b}\right)_{orig}$	Catalogue Values $\left(\frac{1}{a_b}\right)_{orig} - \left(\frac{1}{a}\right)_{osc}$
			°					
1904 I	+0.000216	J S	−144.3	28.8	13.1	Sinding (1935)	+0.000214 ± 0.000011	+0.000718
	+0.000210	J S U N	−160.0	89.8	66.8	Galibina (1963)		
1904 II	+0.000068	V E M J S U N P	−165.8	123.1	105.2	Brady (1965)	+0.000068 ± 0.000040	+0.000217
1905 IV	+0.000045	J S U N	−134.7	22.5	9.5	Bilo, van Houten--Groeneveld (1960)	+0.000044 ± 0.000010	+0.000487
1905 V	+0.000265	V E M J S U N P	−169.5	124.7	105.9	Brady (1965)	+0.000265 ± 0.000151	+0.000445
1905 VI	+0.000621	J S	−146.4	15.5	5.3	Mikhailov (1924)	+0.000638 ± 0.000056	+0.000780
1907 I	+0.000025	E J S	−151.5	33.8	16.0	Strömgren, Rasmusen (1935)	+0.000032 ± 0.000040	+0.000531
	+0.000002	J S U N	−160.0	68.0	44.0	Galibina (1963)		
	+0.000032	V E M J S U N P	−165.3	124.8	107.2	Brady (1965)		
1908 III	+0.000158	Me V E M J S U N	−162.6	41.2	20.6	van Biesbroeck (1943)	+0.000159 ± 0.000079	+0.000891
	+0.000161	J S U N	−162.3	40.1	19.7	Galibina (1963)		
1910 I	+0.000692	Me V E M J S	−172.4	29.5	12.1	Sinding (1948)[24]	+0.000340 ± 0.000101	+0.000300
	+0.000112	J S U N	−171.9	25.9	9.9	Galibina (1963)		
1910 III	+0.000473	J S U N	−146.3	23.1	9.3	Bilo, van Houten-Groeneveld (1960)	+0.000472 ± 0.000007	+0.000376
1911 IV	−0.000157	V E J S U N	−168.0	27.6	11.1	van Houten-Groeneveld(1963b)	−0.000156 ± 0.000096	+0.000405
	−0.000145	J S U N	−168.1	28.5	11.6	Galibina (1964)		
1912 II	+0.001356	V E J S U N	−161.3	27.2	11.0	Bilo, van Houten-Groeneveld (1960)	+0.001357 ± 0.000018	+0.000679
	+0.001359	V E J S U N	−167.3	58.5	34.1	Galibina (1964)		
1914 III	−0.000094	J S U N	−160.0	124.3	111.1	Galibina (1958)	−0.000081 ± 0.000079	+0.000899
	−0.000066	J S U N	−128.3	19.7	8.3	Bilo, van Houten-Groeneveld (1960)		

General Catalogue of Original and Future Comet Orbits. Part E (continued)

Comet	$\left(\frac{1}{a_b}\right)_{orig}$	Perturbing planets	v_{orig}	r_{orig}	int pert.	Reference	Catalogue Values $\left(\frac{1}{a_b}\right)_{orig}$	Catalogue Values $\left(\frac{1}{a_b}\right)_{orig} - \left(\frac{1}{a}\right)_{osc}$
1914 V	+0.000012	J S	-163.0°	50.6	27.9	van Biesbroeck (1927)	+0.000022 ± 0.000003	+0.000168
	+0.000028	J S U N	−166.2	76.1	50.9	Galibina (1963)		
	+0.000022	V E M J S U N P	−169.5	131.7	114.8	Brady (1965)		
1915 II	+0.000140	J S U N	−154.3	20.4	6.9	Bilo, van Houten-Groeneveld (1960)	+0.000134 ± 0.000061	+0.000368
	+0.000130	J S U N	−162.3	42.6	21.2	Galibina (1963)		
1917 III	+0.000021	V E J S U N	−150.1	25.4	10.2	Bilo, van Houten-Groeneveld (1960)	+0.000017 ± 0.000007	−0.000282
	+0.000002	J S U N	−160.0	55.9	32.5	Galibina (1963)		
1919 V	+0.000016	V E M J S U N	−161.1	41.4	20.5	Przybylski (1957)	+0.000016 ± 0.000056	+0.000209
	+0.000018	V E J S U N	−155.3	24.3	9.4	Bilo, van Houten-Groeneveld (1960)		
	+0.000013	J S U N	−162.3	47.3	25.0	Galibina (1963)		
1922 II	+0.000002	J S	−155.2	48.9	27.7	Gennaro (1937)	+0.000002 ± 0.000019	+0.000385
	−0.000004	J S U N	−160.0	74.9	51.1	Galibina (1963)		
1924 I	+0.000521	V E M J S U N P	−167.1	138.2	124.5	Brady (1965)	+0.000521[25])	+0.000278
1925 I	+0.000054	Me V E M J S U N	−160.7	39.6	20.1	Strömgren, Rasmusen (1938)	+0.000054 ± 0.000031	+0.000620
	+0.000038	J S U N	−166.2	76.5	51.8	Galibina (1964)		
1925 VI	+0.000066	Me V E M J S U	−133.4	26.7	12.0	Galibina (1953)	+0.000073 ± 0.000018	+0.000537
	+0.000056	Me V E M J S U N	−119.6	16.5	6.0	Shmakova (1953)		
	+0.000071	J S U N	−150.0	62.4	40.0	Barteneva (1955)		
	+0.000073	J S U N	−128.8	22.4	9.3	Bilo, van Houten-Groeneveld (1960)		
1925 VII	+0.000115	V E J S	−147.8	20.3	7.9	van Biesbroeck (1932)	+0.000034 ± 0.000025	+0.000307
	+0.000007	J S U N	−164.7	88.8	64.7	Galibina (1963)		
1927 IV	+0.000653	J S U N	−131.0	21.4	9.3	Bilo, van Houten-Groeneveld (1960)	+0.000649 ± 0.000005	+0.000124
	+0.000643	J S U N	−160.0	122.2	106.0	Galibina (1963)		

General Catalogue of Original and Future Comet Orbits. Part E (continued)

Comet	$\left(\frac{1}{a_b}\right)_{orig}$	Perturbing planets	v_{orig}	r_{orig}	int pert.	Reference	Catalogue Values $\left(\frac{1}{a_b}\right)_{orig}$	Catalogue Values $\left(\frac{1}{a_b}\right)_{orig} - \left(\frac{1}{a}\right)_{osc}$
1930 IV	+0.000515	E J S	−145.0	21.2	8.8	Dirikis (1954)	+0.000528 ± 0.000014	+0.000710
	+0.000539	J S U N	−160.0	68.9	45.3	Galibina (1958)		
	+0.000525	V E M J S U N	−145.6	23.8	10.2	Bilo, van Houten-Groeneveld (1960)		
1932 VI	+0.000222	J S	−132.1	14.0	4.9	van Biesbroeck (1937)	+0.000073 ± 0.000002	+0.000668
	+0.000044	J S	−132.1	14.0	4.9	Sinding (1948)[26]		
	+0.000072	V E M J S U N	−146.0	27.1	11.8	Bilo, van Houten-Groeneveld (1960)		
	+0.000061	J S U N	−160.0	76.7	52.7	Galibina (1963)		
1936 I	+0.000205	V E M J S U N	−141.9	37.9	20.1	van Biesbroeck (1940a)	+0.000113 ± 0.000215	+0.000600
	+0.000017	J S U N	−160.0	134.1	121.7	Galibina (1963)		
1937 IV	+0.000045	V E M J S U N	−148.1	23.0	9.2	Bilo, van Houten-Groeneveld (1960)	+0.000053 ± 0.000020	+0.000145
	+0.000056	J S U N	−160.0	57.5	34.2	Galibina (1963)		
1941 VIII	+0.000083	V E M J S U N	−157.6	23.2	8.9	Pels-Kluyver (1960)	+0.000082 ± 0.000009	+0.000361
1942 IV	+0.000261	V E J S	−142.8	14.2	4.6	Iannini (1945)	+0.000064 ± 0.000011[27])	+0.000682
	+0.000007	J S U N	−164.7	82.0	57.1	Galibina (1964)		
1944 I	−0.00236	V E M J S U N[28])	−159.9	28.6	12.0	Marsden, van Biesbroeck (1963)	−0.002348 ± 0.000381	+0.000676
1944 IV	0.000000	V E M J S U N	−146.5	26.8	12.0	Bilo, van Houten-Groeneveld (1960)	+0.000003 ± 0.000016	+0.000940
	+0.000007	J S U N	−160.0	73.8	50.1	Galibina (1963)		
1946 I	−0.000035	V E M J S U	−158.6	50.4	28.6	Dirikis (1956)	−0.000016 ± 0.000011	+0.000667
	−0.000010	J S U N	−160.0	57.2	33.8	Galibina (1963)		
1946 VI	+0.000045	V E M J S U N	−155.1	24.4	9.8	Pels-Kluyver (1960)	+0.000044 ± 0.000018	+0.000743

General Catalogue of Original and Future Comet Orbits. Part E (continued)

Comet	$\left(\frac{1}{a_b}\right)_{orig}$	Perturbing planets	v_{orig}	r_{orig}	int pert.	Reference	Catalogue Values $\left(\frac{1}{a_b}\right)_{orig}$	Catalogue Values $\left(\frac{1}{a_b}\right)_{orig} - \left(\frac{1}{a}\right)_{osc}$
			°					
1948 I	+0.000087	E J S	−161.7	29.7	12.6	van Biesbroeck (1961)	+0.000094 ± 0.000009	+0.000504
	+0.000090	J S U N	−167.3	61.1	36.5	Galibina (1964)		
	+0.000094	V E M J S U N P	−172.1	156.6	148.1	Brady (1965)		
1948 XI	+0.001305	J S U N	−174.1	50.6	27.2	Galibina (1963)	+0.001296 ± 0.000032	+0.000815
	+0.001303	V E M J S U N	−170.9	21.4	7.6	van Houten-Groeneveld (1963b)		
1949 I	+0.000497	V E M J S U N P	−162.3	104.3	83.2	Sekanina (1966)	+0.000501 ± 0.000009	+0.000232
1949 IV	+0.000734	V E M J S U N P	−162.3	84.8	60.9	Sekanina (1966)	+0.000738 ± 0.000008	+0.000089
1950 I	+0.000238	V E J S U N	−160.0	84.7	60.8	Barteneva (1965)	+0.000241 ± 0.000019	+0.000508
1951 I	+0.000026	J S U N	−160.0	85.3	61.7	Galibina (1963)	+0.000033 ± 0.000005	+0.000504
	+0.000035	V E M J S U N	−142.8	25.3	10.9	van Houten-Groeneveld (1963b)		
1953 III	+0.002958	V E M J S U N P	−168.5	90.1	67.7	Sekanina (1966)	+0.002962 ± 0.000023	+0.000415
1954 V	+0.000139	J S U N	−137.0	33.5	18.7	van Biesbroeck, Marsden (1963a)	+0.000142 ± 0.000018	+0.000479
1955 IV	+0.004355	V E M J S U N	−152.2	24.7	10.1	van Houten-Groeneveld (1963b)	+0.004354 ± 0.000046	+0.000237
1957 III	−0.000058	E J S	−167.6	13.6	3.8	Lyttleton, Hammersley (1963)	−0.000042 [29]	−0.000685
1957 V	+0.002039	V E M J S U N	−165.9	23.6	8.9	van Houten-Groeneveld (1963b)	+0.002038 ± 0.000018	+0.000208
1958 III	+0.000287	V E M J S U N P	−168.2	124.0	105.4	Sekanina (1966)	+0.000291 ± 0.000015	+0.000212
1959 III	−0.000443	E J S	−156.8	30.8	13.7	Marsden (1962)	−0.000548 ± 0.000254	+0.001576
	−0.000589	J S U N	−167.3	103.0	80.0	Galibina (1964)		
1960 II	−0.000188	V E M J S U N [28]	−167.2	40.9	20.0	van Biesbroeck, Marsden (1963b)	−0.000108 ± 0.000022	+0.000462
	−0.000108	V E M J S U N P	−173.7	165.3	160.3	Brady (1965)		

General Catalogue of Original and Future Comet Orbits. Part F

Comet	$\left(\frac{1}{a_b}\right)_{fut}$	Perturbing planets	v_{fut}	r_{fut}	int pert.	Reference	Catalogue Values $\left(\frac{1}{a_b}\right)_{fut}$	$\left(\frac{1}{a}\right)_{osc} - \left(\frac{1}{a_b}\right)_{fut}$	$\left(\frac{1}{a_b}\right)_{orig} - \left(\frac{1}{a_b}\right)_{fut}$
			°						
1844 II	+0.001504	V E M J S U N P	+171.7	161.5	155.2	Brady (1965)	+0.001504 ± 0.000015	−0.001034	−0.000497
1850 I	+0.001099	J S U N	+166.2	74.6	49.5	Galibina (1964)	+0.001109[30])	−0.000047	+0.000781
1853 III	−0.000630	J S U N	+168.8	32.1	13.9	Galibina (1964)	−0.000617 ± 0.000023	−0.000186	+0.000663
1863 VI	+0.000769	J S U N	+164.7	74.5	49.7	Galibina (1963)	+0.000777 ± 0.000052	−0.001272	−0.000744
1864 III	+0.001300	J S U N	+130.0	39.5	19.2	Galibina (1958)	+0.001311 ± 0.000058	−0.000622	−0.000253
1873 V	+0.000790	V E J S U N	+167.2	30.8	13.1	Galibina (1964)	+0.000793 ± 0.000185	−0.000092	+0.000543
1874 III	+0.001805	J S U N	+165.8	43.9	22.3	Galibina (1964)	+0.001818[31])	−0.000072	+0.001398
1880 II	−0.000086	J S U N	+160.0	60.2	36.8	Galibina (1963)	−0.000103 ± 0.000392	−0.000360	+0.000637
	−0.000103	V E M J S U N P	+166.7	134.4	119.7	Brady (1965)			
1886 I	−0.000234	J S U N	+165.8	41.8	21.1	Galibina (1964)	−0.000259 ± 0.000022	−0.000435	+0.000254
	−0.000259	V E M J S U N P	+172.0	131.3	114.1	Brady (1965)			
1886 II	−0.000115	J S U N	+169.6	58.4	34.3	Galibina (1964)	−0.000118 ± 0.000009	−0.000360	+0.000451
	−0.000118	V E M J S U N P	+173.1	131.6	114.2	Brady (1965)			
1886 III	−0.015399	V E M J S U N P	+170.8	131.1	113.6	Brady (1965)	−0.015399 ± 0.001871	+0.000101	+0.000733
1886 IX	+0.000056	J S U N	+165.8	43.1	21.7	Galibina (1964)	+0.000048 ± 0.000028	−0.000624	+0.000036
	+0.000048	V E M J S U N P	+171.8	130.8	113.0	Brady (1965)			
1889 I	−0.000597	J S U N	+160.0	60.2	36.6	Galibina (1958)	−0.000585 ± 0.000061	−0.000107	+0.000620
	−0.000585	V E M J S U N P	+166.3	128.0	110.9	Brady (1965)			
1889 II	+0.001320	J S U N	+160.0	74.8	50.7	Galibina (1958)	+0.001324 ± 0.000043	−0.001180	−0.000338

General Catalogue of Original and Future Comet Orbits. Part F (continued)

Comet	$\left(\frac{1}{a_b}\right)_{fut}$	Perturbing planets	v_{fut}	r_{fut}	int pert.	Reference	Catalogue Values $\left(\frac{1}{a_b}\right)_{fut}$	$\left(\frac{1}{a}\right)_{osc} - \left(\frac{1}{a_b}\right)_{fut}$	$\left(\frac{1}{a_b}\right)_{orig} - \left(\frac{1}{a_b}\right)_{fut}$
			°						
1889 IV	+0.002747	V E M J S U N P	+169.7	128.4	110.4	Brady (1965)	+0.002747[32])	−0.000554	+0.000051
1890 II	+0.000118	J S U N	+160.0	63.3	39.6	Galibina (1963)	+0.000126 ± 0.000010	−0.000341	−0.000037
	+0.000126	V E M J S U N P	+165.9	126.8	109.8	Brady (1965)			
1890 III	−0.002320	V E M J S U N P	+171.1	127.9	109.4	Brady (1965)	−0.002320 ± 0.001398	−0.000158	+0.000178
1892 I	+0.001734	J S U N	+162.3	43.5	22.3	Galibina (1958)	+0.001711 ± 0.000012	−0.000525	-0.000570
	+0.001711	V E M J S U N P	+169.7	126.3	107.8	Brady (1965)			
1892 II	+0.000543	J S U N	+160.0	65.4	41.4	Galibina (1958)	+0.000523 ± 0.000033	−0.000698	+0.000333
	+0.000523	V E M J S U N P	+165.6	125.3	107.7	Brady (1965)			
1893 I	−0.001203	J S U N	+164.7	67.8	43.0	Galibina (1963)	−0.001197 ± 0.000617	−0.000130	+0.000372
	−0.001197	V E M J S U N P	+168.8	125.5	107.0	Brady (1965)			
1893 II	+0.001784	J S U N	+168.9	71.6	46.0	Galibina (1964)	+0.001797[33])	−0.001000	−0.000805
1896 I	−0.001062	V E M J S U N P	+172.1	123.7	103.8	Brady (1965)	−0.001062 ± 0.000639	−0.000039	+0.000789
1897 I	−0.000766	J S U N	+166.2	73.3	48.1	Galibina (1964)	−0.000755 ± 0.000048	−0.000127	+0.000804
	−0.000755	V E M J S U N P	+169.3	122.4	102.9	Brady (1965)			
1898 I	+0.017734	V E M J S U N P	+169.1	121.4	101.8	Brady (1965)	+0.017734 ± 0.000064	+0.000175	+0.000802
1898 VII	−0.000775	J S	+161.1	62.9	39.2	Sinding (1953)	−0.000774 ± 0.000010	+0.000167	+0.000776
	−0.000766	J S U N	+160.0	56.4	33.4	Galibina (1958)			
	−0.000774	V E M J S U N P	+166.3	120.5	101.5	Brady (1965)			
1898 VIII	+0.000683	V E M J S U N P	+164.1	119.9	101.1	Brady (1965)	+0.000683 ± 0.000081	−0.000401	−0.000691
1898 X	+0.000593	V E M J S U N P	+170.9	121.2	101.2	Brady (1965)	+0.000593 ± 0.000344	−0.000252	+0.000754

General Catalogue of Original and Future Comet Orbits. Part F (continued)

Comet	$\left(\frac{1}{a_b}\right)_{fut}$	Perturbing planets	v_{fut}	r_{fut}	int pert.	Reference	Catalogue Values		
							$\left(\frac{1}{a_b}\right)_{fut}$	$\left(\frac{1}{a}\right)_{osc} - \left(\frac{1}{a_b}\right)_{fut}$	$\left(\frac{1}{a_b}\right)_{orig} - \left(\frac{1}{a_b}\right)_{fut}$
			°						
1899 I	−0.00130	J S U N	+168.1	30.5	12.9	Galibina (1958)	−0.001232 ± 0.000018	+0.000159	+0.001123
	−0.00129	V E J S U N	+169.3	37.9	17.8	Galibina (1964)			
	−0.001232	V E M J S U N P	+174.1	121.4	100.8	Brady (1965)			
1900 II	−0.000566	V E M J S U N P	+169.4	119.6	99.4	Brady (1965)	−0.000566 ± 0.000105	+0.000157	+0.001176
1901 I	+0.001051	V E M J S U N P	+174.8	119.8	98.7	Brady (1965)	+0.001051 ± 0.000766	−0.000183	+0.000027
1902 III	+0.000875	J S U N	+168.8	42.0	31.8	Galibina (1964)	+0.000867 ± 0.000018	−0.000786	−0.000840
	+0.000867	V E M J S U N P	+173.3	118.4	97.1	Brady (1965)			
1903 I	+0.000993	J S U N	+167.2	32.9	14.5	Galibina (1964)	+0.001006[34)]	−0.000192	+0.000061
1904 I	+0.000510	J S	+144.1	28.5	13.0	Sinding (1945)	+0.000525 ± 0.000011	−0.001029	−0.000311
	+0.000523	J S U N	+160.0	89.8	66.5	Galibina (1958)			
1904 II	+0.000314	V E M J S U N P	+165.3	115.3	94.8	Brady (1965)	+0.000314 ± 0.000040	−0.000463	−0.000246
1905 IV	−0.000515	J S U N P	+149.1	47.7	27.1	Sekanina (1966)	−0.000511 ± 0.000009	+0.000068	+0.000555
1905 V	−0.000038	V E M J S U N P	+169.0	115.3	94.1	Brady (1965)	−0.000038 ± 0.000151	−0.000142	+0.000303
1907 I	−0.000277	J S U N	+160.0	68.0	44.0	Galibina (1958)	−0.000283 ± 0.000040	−0.000216	+0.000315
	−0.000283	V E M J S U N P	+164.5	113.2	92.8	Brady (1965)			
1908 III	−0.000422	J S U N	+162.3	40.1	19.7	Galibina (1958)	−0.000411 ± 0.000080	−0.000321	+0.000570
1910 I	+0.000657	J S U N	+171.1	21.4	7.5	Galibina (1963)	+0.000669 ± 0.000102	−0.000629	−0.000329
1911 IV	+0.000102	J S U N	+168.1	28.5	11.5	Galibina (1964)	+0.000115 ± 0.000097	−0.000676	−0.000271
1912 II	+0.000962	V E J S U N	+167.3	58.5	34.2	Galibina (1964)	+0.000966 ± 0.000019	−0.000288	+0.000391

General Catalogue of Original and Future Comet Orbits. Part F (continued)

Comet	$\left(\frac{1}{a_b}\right)_{fut}$	Perturbing planets	v_{fut}	r_{fut}	int pert.	Reference	Catalogue Values		
							$\left(\frac{1}{a_b}\right)_{fut}$	$\left(\frac{1}{a}\right)_{osc}-\left(\frac{1}{a_b}\right)_{fut}$	$\left(\frac{1}{a_b}\right)_{orig}-\left(\frac{1}{a_b}\right)_{fut}$
			o						
1914 III	−0.000122	J S U N	+160.0	124.3	110.9	Galibina (1958)	−0.000120 ± 0.000079	−0.000860	+0.000039
1914 V	+0.000126	J S U N	+160.6	39.0	19.0	van Biesbroeck (1945)	+0.000056 ± 0.000003	−0.000202	−0.000034
	+0.000050	J S U N	+162.3	46.8	24.9	Galibina (1958)			
	+0.000056	V E M J S U N P	+168.4	107.7	85.2	Brady (1965)			
1915 II	+0.001007	J S U N	+162.3	42.6	22.0	Galibina (1958)	+0.001018 ± 0.000063	−0.001252	−0.000884
1917 III	+0.000771	J S U N	+160.0	55.9	33.0	Galibina (1963)	+0.000776 ± 0.000012	−0.000477	−0.000759
1919 V	−0.000052	J S U N	+162.3	47.3	25.5	Galibina (1958)	−0.000043 ± 0.000057	−0.000150	+0.000059
1922 II	−0.000525	J S U N	+160.0	74.9	50.5	Galibina (1963)	−0.000521 ± 0.000020	+0.000138	+0.000523
1924 I	+0.000148	V E M J S U N P	+164.7	99.0	75.5	Brady (1965)	+0.000148[35])	+0.000095	+0.000373
1925 I	−0.000536	J S U N	+162.3	47.0	24.5	Galibina (1958)	−0.000526 ± 0.000034	−0.000040	+0.000580
1925 VI	+0.000199	J S U N	+150.0	62.4	41.0	Barteneva (1955)	+0.000202 ± 0.000018	−0.000666	−0.000129
1925 VII	−0.000335	J S U N	+164.7	88.8	64.2	Galibina (1963)	−0.000328 ± 0.000025	+0.000055	+0.000362
1927 IV	+0.001102	J S U N	+160.0	122.2	105.6	Galibina (1963)	+0.001104 ± 0.000007	−0.000579	−0.000455
1930 IV	−0.000045	J S U N	+160.0	68.9	44.4	Galibina (1958)	−0.000040 ± 0.000016	−0.000142	+0.000568
1932 VI	−0.000217	J S U N	+160.0	76.7	52.6	Galibina (1958)	−0.000213 ± 0.000008	−0.000382	+0.000286
1936 I	−0.000286	J S U N	+160.0	134.1	121.7	Galibina (1958)	−0.000284 ± 0.000215	−0.000203	+0.000397
1937 IV[36])	+0.001355	J S U N	+160.0	57.5	34.2	Galibina (1958)	+0.001361 ± 0.000023	−0.001453	−0.001308

General Catalogue of Original and Future Comet Orbits. Part F (continued)

Comet	$\left(\frac{1}{a_b}\right)_{fut}$	Perturbing planets	v_{fut}	r_{fut}	int pert.	Reference	Catalogue Values $\left(\frac{1}{a_b}\right)_{fut}$	Catalogue Values $\left(\frac{1}{a}\right)_{osc}-\left(\frac{1}{a_b}\right)_{fut}$	Catalogue Values $\left(\frac{1}{a_b}\right)_{orig}-\left(\frac{1}{a_b}\right)_{fut}$
			°						
1942 IV	−0.000847	J S U N	+164.7	82.0	57.1	Galibina (1964)	−0.000840 ± 0.000012	+0.000222	+0.000904
1944 IV	−0.000531	J S U N	+160.0	73.8	49.3	Galibina (1963)	−0.000527 ± 0.000018	−0.000410	+0.000530
1946 I	+0.000329	J S U N	+160.0	57.2	33.9	Galibina (1963)	+0.000335 ± 0.000013	−0.001018	−0.000351
1946 VI	+0.000017	V E M J S U N P	+165.9	76.7	51.0	Sekanina (1966)	+0.000020 ± 0.000018	−0.000719	+0.000024
1948 I	−0.000317	E J S	+161.7	29.7	12.6	van Biesbroeck (1961)	−0.000297 ± 0.000009	−0.000113	+0.000391
	−0.000300	J S U N	+167.3	61.1	36.5	Galibina (1964)			
	−0.000297	V E M J S U N P	+168.7	77.4	51.9	Brady (1965)			
1948 XI	+0.000496	J S U N	+171.1	22.5	8.0	Galibina (1963)	+0.000508 ± 0.000037	−0.000027	+0.000788
1949 I	+0.000579	V E M J S U N P	+156.7	61.4	51.0	Sekanina (1966)	+0.000583 ± 0.000009	−0.000314	−0.000082
1949 IV	+0.000953	V E M J S U N P	+156.9	50.8	29.1	Sekanina (1966)	+0.000957 ± 0.000008	−0.000308	−0.000219
1950 I	+0.000529	V E J S U N	+160.0	84.7	61.3	Barteneva (1965)	+0.000532 ± 0.000019	−0.000799	−0.000291
1951 I	+0.000275	J S U N	+160.0	85.3	61.7	Galibina (1963)	+0.000279 ± 0.000009	−0.000750	−0.000246
1953 III	+0.003197	V E M J S U N P	+167.2	74.9	51.1	Sekanina (1966)	+0.003201 ± 0.000023	−0.000654	−0.000239
1958 III	+0.001832	V E M J S U N P	+164.4	71.0	46.3	Sekanina (1966)	+0.001836 ± 0.000015	−0.001757	−0.001545
1959 III	−0.001898	J S U N	+167.3	103.0	79.8	Galibina (1964)	−0.001890 ± 0.000254	−0.000234	+0.001342
1960 II	−0.000560	V E M J S U N P	+169.9	65.0	39.7	Brady (1965)	−0.000560 ± 0.000022	−0.000010	+0.000452

Notes on the Catalogue

[1]) Unpublished by VON REBEUR-PASCHWITZ. In accordance with BILO and VAN HOUTEN-GROENEVELD (1960) it was adopted $T_{osc} = T$.

[2]) The KOBOLD orbit is a re-treatment of the observational data originally collected by FURNESS and WATERMAN (1908). No planetary perturbations have been applied, since the comet had approached no planet when orbitting round the Sun. The perturbations have not been appreciable and no date of osculation has therefore been published. The middle of the period of observation is 1886 May 18.

[3]) The perturbations by the Earth were investigated by ZAPPA and found to be within observational errors. The middle of the period of observation is 1905 December 9.

[4]) Nothing is mentioned by CAMPA as for including planetary perturbations and the date of osculation. The middle of the period of observation is 1924 July 2.

[5]) Nothing is mentioned by HASEGAWA as for including planetary perturbations and the date of osculation. The middle of the period of observation is 1957 March 9.

[6]) No root-mean-square error published by CARRINGTON.

[7]) No root-mean-square error published by VON HEPPERGER.

[8]) Small planetary perturbations included by VON REBEUR-PASCHWITZ. No detail mentioned.

[9]) No root-mean-square error published by HORN.

[10]) No root-mean-square error published by KROMM.

[11]) Neither a root-mean-square error of the reciprocal semi-major axis nor a mean residual is remarked by BRUCK.

[12]) Perturbations included. No detail, however, is given by SEDLÁČEK.

[13]) No root-mean-square error published by PEISINO and DE CARO.

[14]) No root-mean-square error published by CAMPA.

[15]) The value was privately communicated by Dr. MARSDEN (1966).

[16]) Neither a root-mean-square error of the reciprocal semi-major axis nor a mean residual is remarked by HASEGAWA.

[17]) The root-mean-square error given was published in LYTTLETON'S and HAMMERSLEY'S paper (LYTTLETON, HAMMERSLEY 1963), in a list of 42 comets compiled by B. G. MARSDEN. For another estimate of the error see MARSDEN (1962).

[18]) Additional error ± 0.000014. The total error unknown, see Note [6]).

[19]) Additional error ± 0.000017. The total error unknown, see Note [7]).

[20]) Not reduced to the barycentre.

[21]) No additional error in units of the sixth decimal. The total error unknown, see Note [9]).

[22]) Additional error ± 0.000017. The total error unknown, see Note [10]).

[23]) Additional error ± 0.000017. The total error unknown, see Note [11]).

[24]) LOUS (1924) gave originally a value of $+0.003302$. His computations were, however, later on revised by SINDING (1948) who found a mistake. The value of $+0.000692$ is that corrected by SINDING. It is not known how the obvious discrepancy between this corrected value and that published by GALIBINA could be explained. The catalogue value is, therefore, very uncertain.

[25]) No additional error in units of the sixth decimal. The total error unknown, see Note [14]).

[26]) This value was not computed by SINDING. In the mentioned paper the original value of $\frac{1}{a}$ is included together with others in a table, based on a list of 21 rigorous calculations of the eccentricities of original orbits, summarized on page 285 of a text-book by GEELMUYDEN and STRÖMGREN, named "Loerebog i Astronomi, 2. Udg., Oslo, 1945". As mentioned by SINDING, in most of the 21 cases only Jupiter's and Saturn's gravitational influences have been considered. In the present catalogue, the data given in the respective line in columns 2 to 6 are identical with those of VAN BIESBROECK'S determination, in accordance with a remark by BILO and VAN HOUTEN-GROENEVELD (1960).

[27]) It is not clear how the discrepancy between the values by IANNINI and GALIBINA could be explained. The catalogue value is very uncertain.

[28]) The perturbing planets included were communicated to the author privately by Dr VAN BIESBROECK.

[29]) This value was computed by MARSDEN but never published elsewhere (MARSDEN 1966). Columns 2 to 6 were completed thanks to the data Dr MARSDEN kindly gave at my disposal. Additional error ±0.000024. The total error unknown, see Note[16]). MARSDEN accounts this value rough because of the uncertain initial orbit and a short period of integration.

[30]) Additional error ±0.000014. The total error unknown, see Note [6]).

[31]) Additional error ±0.000017. The total error unknown, see Note [7]).

[32]) No additional error in units of the sixth decimal. The total error unknown, see Note [9]).

[33]) Additional error ±0.000017. The total error unknown, see Note [10]).

[34]) Additional error ±0.000017. The total error unknown, see Note [11]).

[35]) No additional error in units of the sixth decimal. The total error unknown, see Note [14]).

[36]) The future values for Comets 1937 IV and 1941 VIII included in Table I of LYTTLETON'S and HAMMERSLEY'S paper (LYTTLETON, HAMMERSLEY 1963) are misprints (MARSDEN 1966).

The Catalogue does not include Comet 1931 V. The original value was computed by HERGET (1934b) on the basis of his osculating orbit (HERGET 1934a), but the period of integration was too short.

The Catalogue does not, in addition, include the future orbit of Comet 1905 VI as computed by the author (SEKANINA 1966). The step of integration was chosen too large to prevent from considerable interpolation errors in the course of the integration procedure.

References

BARTENEVA O. N., 1955, BIA 6, 249.
— 1965, BIA 10, 443.
BELOUS L. M., 1964, BIA 9, 569.
VAN BIESBROECK G., 1927, Publ. Yerkes Obs. 5, Pt 2, 1.
— 1932, AJ 41, 91.
— 1937, Publ. Yerkes Obs. 8, Pt 3, 1.
— 1940a, Publ. Yerkes Obs. 8, Pt 4, 1.
— 1940b, Publ. Yerkes Obs. 8, Pt 4, 10.
— 1943, Publ. Yerkes Obs. 8, Pt 5, 1.
— 1945, ApJ 101, 376.
— 1961, AJ 66, 424.
VAN BIESBROECK G., MARSDEN B. G., 1963a, AJ 68, 212.
— 1963b, AJ 68, 566.
BILO E. H., VAN HOUTEN-GROENEVELD I., 1960, BAN 15, 155.
BILO E. H., VAN DE HULST H. C., 1960, BAN 15, 119.
BRADY J. L., 1965, AJ 70, 279.
BRUCK P., 1907, BA 24, 277.
— 1908, BA 25, 129.
BUSCHBAUM C., 1889, Untersuchungen über die Bahn des Kometen 1886 IX. Göttingen.
BÜTTNER H., 1918, AN 207, 179.
— 1922, Astr. Abh. 4, No 1.
CAMPA M., 1931, Publ. Oss. Trieste 2, 69.
CARRINGTON R. C., 1854, AN 37, 41.
CHANDRASEKHAR S., 1944, ApJ 99, 54.
CHIS G., 1950, Publ. Obs. Astr. Cluj No 7.
CURTIS H., 1902, Astr. Abh. 1, No 3, 1.
DIRIKIS M. A., 1954, AJ UdSSR 31, 461.
— 1956, Trudy astr. sekt. AN Latv. SSR 6, 5.
DUBROWSKY K., NUMEROW B., 1913, AN 195, 273.
FABRY L., 1894, BA 11, 485.
FAYET G., 1910, Ann. Obs. Paris, Mémoirs 26, 1.
— 1933, Ann. Bureau Longitudes 10.
VON FLOTOW A., 1902, AN 160, 217.

FURNESS C. E., WATERMAN E. P., 1908, Astr. Abh. 1, No 14, 27.
GALIBINA I. V., 1953, BIA 5, 412.
— 1958, BIA 6, 630.
— 1963, BIA 9, 46.
— 1964, BIA 9, 465.
GALIBINA I. V., BARTENEVA O. N., 1965, BIA 10, 192.
GENNARO A., 1936a, Publ. Oss. Astr. Padova No 50.
— 1936b, AN 259, 311.
— 1937, Publ. Oss. Astr. Padova No 54.
GRUBISSICH C., 1951, Mem. Soc. Astr. Italiana 22, 251.
— 1953, Publ. Oss. Astr. Padova No 97.
HASEGAWA I., 1957, Circ IAU No 1619.
VON HEPPERGER J., 1882, Sitzungsber. Math. Nat. Classe Akad. Wiss. Wien 86 (2), 451.
HERGET P., 1934a, AJ 43, 39.
— 1934b, AJ 43, 128.
HIRST W. P., 1954, MNASSA 13, 31.
HORN G., 1904, AN 165, 327.
VAN HOUTEN-GROENEVELD I., 1963a, BAN 17, 223.
— 1963b, BAN 17, 240.
HRISTOFF W., 1926, Dissertation. Sofia.
IANNINI G. M., 1945, Publ. Obs. La Plata 21, No 2, 1.
KASAKOV S., 1926, Ann. Obs. Astr. Moscou, Ser. 2, 8, 18.
KENDALL D. G., 1961, Proc. Fourth Berkeley Symp. Math. Statistics Prob. 3, 87.
KOBOLD H., 1909, AN 182, 33.
KREUTZ H., 1888, Untersuchungen über das System der Kometen 1843 I, 1880 I und 1882 II. Theil 1. Kiel.
— 1894, Publ. Sternwarte Kiel 9, No 2, 19.
KROMM F., 1895, BA 12, 76.
KÜHNE E. E., 1914, AN 197, 139.
LOUS K., 1924, AN 220, 167.
LYTTLETON R. A., HAMMERSLEY J. M., 1963, MN 127, 257.
MAKOVER S. G., 1955, BIA 6, 244.
MARSDEN B. G., 1962, JBAA 72, 139.
— 1963a, Circ IAU No 1818.
— 1963b, Circ IAU No 1838.
— 1966, private communication.
MARSDEN B. G., VAN BIESBROECK G., 1963, AJ 68, 235.
DE MELLO E SIMAS M. S., 1903, Astr. Abh. 1, No 4, 1.
— 1912, AN 192, 341.
MERFIED C. J., 1901, AN 154, 229.
— 1902a, AN 157, 33.
— 1902b, AN 157, 123.
— 1903, Astr. Abh. 1, No 4, 17.
MIKHAILOV A., 1924, AJ UdSSR 1, 56.
MÖLLER J., 1901, Astr. Abh. 1, No 2, 1.
— 1906, AN 171, 47.
OGURA S., KANEKO H., 1914, AN 200, 153.
OORT J. H., SCHMIDT M., 1951, BAN 11, 259.
ORKISZ L., 1933, Warsaw Reprint No 21.
PECK H. A., LINDSEY L., 1911, AJ 27, 1.
PEISINO G., DE CARO E., 1931, Publ. Oss. Trieste 2, 87.
PELS G., 1947, BAN 10, 229.
— 1960, BAN 15, 127.
PELS-KLUYVER H. A., 1960, BAN 15, 163.
POLAK J., 1911, AN 189, 7.
— 1913, AN 193, 393.

— 1925, AJ UdSSR 1, 27.
— 1926, Ann. Obs. Astr. Moscou, Ser. 2, 8, 1.
PORTER J. G., 1961, Mem. BAA 39, No 3.
PRZYBYLSKI A., 1939, Acta Astr., Ser. A, 4, 34.
— 1956, Acta Astr., Ser. C, 6, 117.
— 1957, Acta Astr., Ser. C, 7, 246.
DU PUI J. C., 1932, Loopbaan van der Komeet Wolf (1916b = 1917 III). Utrecht.
— 1933, JBAA 43, 303.
RASMUSEN H. Q., 1937, Publ. Københavns Obs. No 112.
— 1952, Publ. Københavns Obs. No 158.
VON REBEUR-PASCHWITZ E., 1887, AN 117, 281.
REDLICH E., 1911, AN 187, 193.
ROSÉN P. G., 1867, AN 68, 145.
ROSENBAUM L., 1917, Astr. iaktt. Stockholms Obs. 10, No 5.
ROSS F. E., 1905, Astr. Abh. 1, No 9, 1.
SAKK V. V., KULIKOV D. K., 1951, BIA 4, 431.
SCHARBE S., 1903, AN 164, 377.
SCHROETER J. F., 1905, Skrift. Vid.-Selsk. Christ., Math.-Nat. Klasse, No 1.
SCHRUTKA-RECHTENSTAMM G., 1960a, Circ IAU No 1740.
— 1960b, Mitt. Univ. Sternwarte Wien 11, 35.
SCHUBART J., 1961, AN 286, 79.
SEDLÁČEK J., 1910, AN 186, 193.
SEKANINA Z., 1966, BAC 17, 67.
SHMAKOVA M. J., 1953, BIA 5, 420.
SHEN Z., IMAI I., 1934, Journ. Shanghai Sci. Inst., Sect. 1, 1, 29.
SINDING E., 1935, Publ. Københavns Obs. No 105.
— 1945, Mat. Tidsskrift B, 124.
— 1948, Publ. Københavns Obs. No 146.
— 1953, Publ. Københavns Obs. No 161.
STEINER L., 1898, AN 145, 247.
STRÖMGREN E., 1896, Acta Reg. Soc. Phys. Lund 6, 1.
— 1898, Medd. Lunds Obs. No 1.
— 1899a, Medd. Lunds Obs. No 7.
— 1899b, AN 151, 65.
STRÖMGREN E., RASMUSEN H. Q., 1935, Publ. Københavns Obs. No 98.
— 1938, Publ. Københavns Obs. No 114.
SVÄRDSON J., 1917, Astr. iaktt. Stockholms Obs. 10, No 6.
THRAEN A., 1893, AN 132, 241.
— 1894, AN 136, 133.
VIARO M., 1936, Capodimonte Contr. Ser. 2, No 12.
— 1938, Mem. Mat. Fis. Nat. Soc. Ital., Ser. 3, 24, 63.
WASNETZOFF M., 1914, AN 197, 121.
WIERZBIŃSKI S., 1961, Circ IAU No 1772.
— 1962, Wroclaw Astr. Obs. Reprint No 40.
VAN WOERKOM A., 1948, BAN 10, 464.
ZAPPA G., 1906a, Ann Oss. Astr. Coll. Romano, Ser. 3, 4, Pt 2, 97.
— 1906b, AN 174, 187.
ZWECK F. K., 1926, AN 227, 221.

Obecný katalog původních a budoucích drah komet

Souhrn

Obecný katalog původních a budoucích drah komet obsahuje důležité údaje o původních drahách 81 komet a o budoucích drahách 70 komet. Navíc jsou v katalogu uvedeny i údaje o definitivních drahách, jež byly výchozím bodem výpočtů. V práci jsou dále srovnány vlastní výpočty pertubací s teorií a diskutuje se dosažená přesnost a výsledné průměrné opravy na planetární perturbace. Analyzují se rozdělení četnosti změn energie komet, způsobené působením planet a srovnávají se s výsledky teoretických úvah. Závěrem je zkoumána otázka možného mezihvězdného původu některých komet.

Общий каталог первоначальных и будущих орбит комет

Резюме

В настоящей работе приводится Общий каталог первоначальных и будущих орбит комет, содержащий важные данные о первоначальных орбитах 81 комет и о будущих орбитах 70 комет. Кроме того каталог содержит данные об окончательных орбитах, с которых начались вычисления. Подробно рассматривается точность, с которой орбиты получились и после сравнения прямых вычислений с теорией приводятся результирующие средние поправки за планетные возмущения. В дальнейшем исследуются изменения энергии комет вызванные планетными возмущениями и сравниваются с результатами теоретических рассуждений. Наконец изучается вопрос возможного межзвездного происхождения некоторых комет.