A&A 567, A126 (2014)
DOI: 10.1051/0004-6361/201323263

Astronomy & Astrophysics

Warsaw Catalogue of cometary orbits: 119 near-parabolic comets⋆

Małgorzata Królikowska

Space Research Centre of the Polish Academy of Sciences, Bartycka 18A, 00-716 Warsaw, Poland
e-mail: mkr@cbk.waw.pl

Received 17 December 2013 / Accepted 23 May 2014

ABSTRACT

Context. The dynamical evolution of near-parabolic comets strongly depends on the starting values of the orbital elements derived from the positional observations. In addition, when drawing conclusions about the origin of these objects, it is crucial to control the uncertainties of orbital elements at each stage of the dynamical evolution.

Aims. I apply a completely homogeneous approach to determine the cometary orbits and their uncertainties. The resulting catalogue is suitable for the investigation of the origin and future of near-parabolic comets.

Methods. First, osculating orbits were determined on the basis of positional data. Second, the dynamical calculations were performed backwards and forwards up to 250 au from the Sun to derive original and future barycentric orbits for each comet. In the present investigation of dynamical evolution, the numerical calculations for a given object start from the swarm of virtual comets constructed using the previously determined osculating (nominal) orbit. In this way, the uncertainties of orbital elements were derived at the end of numerical calculations.

Results. Homogeneous sets of orbital elements for osculating, original and future orbits are given. The catalogue of 119 cometary orbits constitutes about 70 per cent of all the first class so-called Oort spike comets discovered during the period 1801–2010 and about 90 per cent of those discovered in 1951−2010, for which observations were completed at the end of 2013. Non-gravitational (NG) orbits are derived for 45 comets, including asymmetric NG solution for six of them. Additionally, the new method for cometary orbit-quality assessment is applied for all these objects.

Key words. catalogs – comets: general – Oort Cloud

1. Introduction

This catalogue presents for the first time the osculating, original and future orbital elements of near-parabolic comets that were determined by myself and in their majority were further investigated in collaboration with Piotr A. Dybczyński from the Astronomical Observatory Institute at Poznań. In a series of papers, i.e. Królikowska & Dybczyński (2010, hereafter Paper 1), Dybczyński & Królikowska (2011, Paper 2), Królikowska et al. (2012, Paper 3) and Królikowska & Dybczyński (2013, Paper 4), we focused on the problem of the origin of near-parabolic comets with original inverse semi-major axes inside the so-called Oort spike. Investigating the dynamical orbital evolution of these observed Oort-spike comets to the previous perihelion passage, we showed that only part of them make their first visit into the planetary zone, that is, we found that barely 50 per cent of these comets have a previous perihelion distance below 15 au (Paper 2).

The catalogue presents a homogeneous set of osculating orbits of just such comets, the nongravitational effects were determined for more than 40 per cent of them. The full sample of 119 comets forming this catalogue constitutes almost 70 per cent of all first class so-called Oort spike comets (condition of $1/a_{\rm ori} < 150\times10^{-6}$ au^{-1} was taken with a spare) discovered during the period of 1801–2010, ~90 per cent of those discovered in the years 1951−2010, for which observations were completed at the end of 2013. The completeness of all three subsamples of these comets is presented in more detail in Sect. 3. In the next years the catalogue will be supplemented by comets discovered a long time ago, and will be updated with newly discovered objects after 2010. In particular, the complete sample of comets discovered during the years 1901−1950 is under consideration as an independent project of the New Catalogue of One-Apparition Comets, the first part of which, that includes 38 comets with $1/a_{\rm ori} \leq 0.000130$ au^{-1} according to Marsden & Williams Catalogue (2008, hereafter MWC 08), is completed.

The paper is organized as follows: in the next section, I shortly describe the methods and model of motion applied to orbital determinations. In some cases the non-gravitational (hereafter NG) orbits were determinable, thus a brief description of the adopted model of NG acceleration is given in Sect. 2.1. Since the new method for evaluating the quality of osculating cometary orbits is used in the present catalogue, the accuracy of the cometary orbit is discussed in some detail in Sect. 2.2. The last part of Sect. 2 describes how the original and future orbits and their uncertainties were determined. Section 3 is divided into four parts that deal with tabular parts of the catalogue given in appendices. Thus, this section includes a general description of the observational material of the analysed comets (Part I of the catalogue), as well as osculating orbital elements (Part II), and original and future orbital elements (Parts III and IV). The article ends with concluding remarks on the accuracy of orbital solutions given in the catalogue and future plans (Sect. 4).

This publication is accompanied by an online catalogue also providing entries to full swarms of original and future virtual comets (hereafter VCs, see Sect. 2.3) that formed the basis

⋆ The catalogue is available at ssdp.cbk.waw.pl/LPCs and also at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsarc.u-strasbg.fr/viz-bin/qcat?J/A+A/567/A126 for the detailed analysis of dynamical evolution presented in Papers 1–4. Thus, this catalogue also allows one to construct and analyse the observed distribution of Oort spike comets and to investigate the problem of cometary origin.

2. Methods and assumptions

For each comet from the catalogue, I determined the osculating nominal orbit (GR – pure gravitational or NG if possible; see next subsection) based on the astrometric data, selected and weighted according to the methods described in great detail in Paper 1. This allowed me to construct a homogeneous sample of cometary osculating orbits as well as homogeneous samples of original and future orbits.

The equations of a comet's motion were integrated numerically using the recurrent power series method (Sitarski 1989, 2002), taking into account perturbations by all the planets (additionally, Pluto was taken into account to be consistent with DE405/WAW) and including the relativistic effects. All orbital calculations performed for this catalogue were based on the Warsaw numerical ephemeris DE405/WAW of the solar system (Sitarski 2002), consistent with a high accuracy with the JPL ephemeris DE405.

2.1. Nongravitational model of motion applied to orbit determination

To determine the NG cometary orbit the standard formalism proposed by Marsden et al. (1973, hereafter MSY) was used where the three orbital components of the NG acceleration acting on a comet are scaled with a function $g(r)$ symmetric relative to perihelion:

$$F_i = A_i \cdot g(r), \qquad A_i = \text{ const. for } \quad i = 1, 2, 3, \tag{1}$$

$$g(r) = \alpha\, (r/r_0)^{-2.15} \left[1 + (r/r_0)^{5.093}\right]^{-4.614}, \tag{2}$$

where F_1, F_2, F_3 are the radial, transverse and normal components of the NG acceleration, respectively, and the radial acceleration is defined outward along the Sun-comet line. The normalization constant $\alpha = 0.1113$ gives $g(1 \text{ AU}) = 1$; the scale distance $r_0 = 2.808$ AU. From orbital calculations, the NG parameters A_1, A_2, and A_3 were derived together with six orbital elements within a given time interval (numerical details are described in Królikowska 2006). The standard NG model assumes that water sublimates from the whole surface of an isothermal cometary nucleus. The asymmetric model of NG acceleration is derived by using function $g(r(t-\tau))$ instead of $g(r(t))$. Thus, this model introduces an additional NG parameter τ – the time displacement of the maximum of the $g(r)$ relative to the moment of perihelion passage.

In the present catalogue, NG solutions were determined for 45 near-parabolic comets, including asymmetric NG solution for six of them (C/1959 Y1, C/1990 K1, C/1993 A1, C/2007 N3, C/2007 W1 and C/2008 A1). Moreover, 66 per cent of comets with small perihelion distance have NG orbits in the catalogue (33 of 50; see samples A1 and A2 in Sect. 3.1 and Table A.1).

NG parameters for all NG solutions given in this catalogue are presented in Table B.4 in Part II of this catalogue. One can see in Fig. 1 that NG accelerations at perihelion derived for near-parabolic comets are below the 10^{-3} of solar gravitational acceleration with a typical value of about $10^{-4} \cdot F_{\odot}$.

2.2. Accuracy of the cometary orbit

In 1978 Marsden et al. (1978, hereafter MSE) formulated the recipe to evaluate the accuracy of the osculating cometary orbits obtained from the positional data. They proposed to measure this accuracy by the quantity Q defined as

$$Q = Q^* + \delta, \quad \text{where}$$
$$Q^* = 0.5 \cdot (L + M + N) \quad \text{ and } \delta = \text{ 1 or 0.5} \tag{3}$$

to make Q an integer number, and L denotes a small integer number that depends on the mean error of the determination of the osculating $1/a$, M is a small integer number that depends on the time interval covered by the observations, and N is a small integer number that reflects the number of planets whose perturbation were taken into account.

Values of L, M and N are obtained following the scheme presented in the original Table II given by MSE. The integer Q-value calculated from Eq. (3) should next be replaced with the orbit quality class as follows: a value of $Q = 9, 8$ means orbit of orbital class 1A, $Q = 7$ of class 1B, $Q = 6$ of class 2A, $Q = 5$ of class 2B, and $Q < 5$ means lower than second-class orbit.

In Paper 4 we discussed three reasons for which we found that some modifications of the above recipe of orbital accuracy estimation should be done. Briefly, these are the following:

1. In the modern orbit determination all solar system planets are always taken into account, therefore we always have $N = 3$.
2. Current cometary positional observations are generally of significantly higher precision than 30 years ago. Moreover, modern LPCs are often observed much longer in time than the four years predicted by MSE in their scheme. Thus, the possibility of arbitrarily low values of a mean error of $1/a_{\rm osc}$ and an arbitrarily long time span of observations should be included to the original Table II given by MSE.
3. Almost all orbits of currently discovered LPCs should be classified as quality class 1A using the MSE quality scheme. Therefore, a better diversification between orbit accuracy classes is necessary. We realized this postulate by new δ-definition and introducing three quality classes 1a+, 1a and 1b instead of the former 1A and 1B.

The final form of a new orbital quality scheme was constructed after an inspection of orbital uncertainties and data intervals in the sample of 22 comets discovered in the years 2006−2010 (Paper 4), and samples of near-parabolic comets from Papers 1−3. The new scheme proposed in Paper 4 is based on a slightly modified Eq. (3):

$$Q = Q^* + \delta, \quad \text{where}$$
$$Q^* = 0.5 \cdot (L + M + 3) \quad \text{ and } \quad \delta = \text{ 0 or 0.5}, \tag{4}$$
$$\text{to make } Q \text{ an integer number.}$$

To distinguish the proposed quality system from the MSE system, in Paper 4 we used the lower-case letters "a" and 'b" in quality class descriptions instead of the original "A" and "B" in the following way: $Q = 9$ – class 1a+, $Q = 8$ – class 1a, $Q = 7$ – class 1b, $Q = 6$ – class 2a, $Q = 5$ – class 2b, $Q = 4$ – class 3a, $Q = 3$ – class 3b, and $Q \leq 2$ – class 4, where Q is calculated according to Eq. (4). The quality classes 3a, 3b and 4 were not defined by MSE, but we adopted here the idea published by IAU Minor Planet Center Web Pages (2013) as "a logical extension to the MSE scheme".

How to calculate the quantities L and M is described in Table 1, which is a simpler form of the original Table II given

Table 1. Quantities for establishing accuracy of orbit.

L & M	Mean error of $1/a_{\rm osc}$ in units of 10^{-6} au^{-1}	Time span of observations in months or days
8		≥48 months
7	<1	[24 , 48[
6	[1 , 5[	[12 , 24[
5	[5 , 20[	[6 , 12[
4	[20 , 100[	[3 , 6[
3	[100 , 500[	[1.5 , 3[
2	[500 , 2500[	[23 days , 1.5 months[
1	[2500 , 12 500[	[12 , 23[days
0	≥12 500	[7 , 12[
−1		[3 , 7[
−2		[1 , 3[

Notes. This version of the table is taken from Paper 4.

by MSE. We only introduced in this table the possibility of arbitrarily low values of a mean error of $1/a_{\rm osc}$ and an arbitrarily long time span of observations, and, as mentioned before, we completely removed the redundant column describing the number of planets taken into account in the orbit determination process. Instead, we set $N = 3$ in Eq. (4). Thus, the mean error of $1/a_{\rm osc}$ smaller than 1 unit (i.e. 1×10^{-6} au^{-1}) now gives $L = 7$ and a time span of data longer than 48 months results in $M = 8$.

This new orbit quality scheme separates the orbits of very good quality in MSE system, 1A, into three quality classes in the new system, where the lowest of orbits in class 1A ($Q^* = 7$) in the MSE system are classified as 1b in the new scheme.

2.3. Original and future orbits

To calculate the original and future orbital elements as well as their uncertainties (taken at 250 au from the Sun where planetary perturbations are negligible) the dynamical calculations for swarms of starting osculating orbits were performed for each catalogue comet. Each swarm was constructed according to the Monte Carlo method proposed by Sitarski (1998), where the entire swarm fulfil the Gaussian statistics of fitting to positional data used for a given osculating orbit determination (examples are in Paper 1). Each swarm consists of 5001 VCs including the nominal orbit; this number of orbital clones gives a sufficient sample to obtain reliable statistics at 250 au from the Sun. Values of uncertainties of original/future orbital elements were derived by fitting the distribution of a given orbital element of an original/future swarm of VCs to Gaussian distribution. All distributions of orbital elements including $1/a$ distributions of analysed comets were still perfectly Gaussian at 250 au from the Sun.

3. The catalogue

3.1. Description and structure of tabular materials

To avoid very long tables with dozens of entries in each row it was convenient to divide the tabular material into four general parts.

Part I. Description of the observational material

Table A.1 describes the sets of positional observations taken for each orbit determination and gives the new quality assessment of derived osculating orbits using the scheme proposed in Paper 4. The presentation of considered comets is separated into three samples.

Sample A1

This sample consists of 28 near-parabolic comets of $q_{\rm osc} < 3.1$ au and $1/a_{\rm ori} < 150 \times 10^{-6}$ au^{-1} discovered before the year 2006. Sample A1 is very incomplete and includes 40 per cent of all discovered LPCs that fulfil the above conditions (see Table 2). Most comets from this sample (except for six objects, see Table A.1) have NG orbits, and these solutions are characterized by a clear decrease in root-mean-square error (rms) compared with the rms for GR orbits, only C/1974 F1 displays a slight decrease of rms for NG solution. Orbital solutions for most comets belonging to this sample were used for dynamical evolution discussed in Papers 1–3. However, three comets analysed in these papers (C/1913 Y1, C/1940 R2 and C/1946 U1) are not presented here because they are included in the independent project of the New Catalogue of One-Apparition Comets from the Years 1901–1950, Part I of which is just completed. In the present catalogue the new NG solutions are given for C/1990 K1, C/1993 A1, C/2002 T7 (POST type of data), C/2003 K4, and four new comets are added to the sample analysed previously (C/2001 B1, C/2002 Q5, C/2003 T3, C/2005 E2, Sect. 2.1 and Table A.1.

Sample A2

This is a complete sample of 22 comets of $q_{\rm osc} < 3.1$ au and $1/a_{\rm ori} < 150 \times 10^{-6}$ au^{-1} discovered in the period 2006–2010 (Table 2). NG solutions are determined for eleven of them. These comets were examined in Paper 4.

Sample B

This is an almost complete sample of 69 comets of $q_{\rm osc} > 3.1$ au and $1/a_{\rm ori} < 150 \times 10^{-6}$ au^{-1} discovered in the period 1970–2010; the missing four comets (C/2008 S3, C/2009 F4, C/2010 S1, and C/2010 U3) were still observed at the end of 2013. Orbits of six comets of Sample B were redetermined using longer data intervals than those used in Papers 1–2 (C/1997 A1, C/1999 F1, C/1999 N4, C/1001 J4, C/2003 S3, and C/2005 K1, see notes 3–8 to Table A.1) and the sample was enriched with ten comets in comparison to previous analyses (C/2005 L3, C/2006 S3, C/2007 D1, C/2007 VO$_{53}$, C/2008 FK$_{75}$, C/2008 P1, C/2009 P2, C/2009 U5, C/2010 D3, and C/2010 R1). Twelve comets from this sample have NG orbits in the present catalogue.

Part II. Osculating orbital elements

Tables B.1–B.3 show heliocentric osculating orbital elements for all objects structured in accordance with Table A.1. Table B.4 gives the NG parameters for all comets with NG orbits in the catalogue.

Part III. Original orbital elements

Tables C.1–C.3 include the original barycentric orbits in the same order.

Part IV. Future orbital elements

Tables D.1–D.3 present the future barycentric orbits.

The entire catalogue, that is, all tables given in appendices, is made available also through the Strasbourg Astronomical Data Centre (CDS).

Table 2. Completeness of the sample of comets in the present catalogue in comparison to MWC 08 as a function of the time distribution of cometary discovery (five periods given in Col. [1]) and the perihelion distance (q_{osc} < 3.1 au or $q_{osc} \geq 3.1$ au, Cols. [2], [3] and [4], [5], respectively).

	Number of comets in the different samples					
Period	q_{osc} < 3.1 au		$q_{osc} \geq 3.1$ au		All comets	
of discovery	MWC 08	Samples A1+A2	MWC 08	Sample B	MWC 08	Samples A1+A2+B
(1)	(2)	(3)	(4)	(5)	(6)	(7)
before 1901	11	2	–	–	11	2
1901–1950	26	0	6	–	32	0
1951–2000	25	16	42	34	67	50
2001–2005	9	10	20	20	29	30
2006–2010	12	19 + 3	6	15	18	34 + 3
All	83	47 + 3	74	69	157	116 + 3

Notes. The number of comets is given for objects of first-quality class orbits in MWC 08 (1A or 1B), except for the comets of Sample A2, where 3 objects with orbital quality class 2 and 3 are included; this is indicated by "+ 3" in Cols. [3] and [7]. The upper limit for $1/a_{ori}$ is taken at 0.000150 au^{-1}. All comets with an NG orbit in MWC 08 (in this case the $1/a_{ori}$ is not given there) were also analysed and some of them have $1/a_{ori}$ < 0.000150 au^{-1}. The sample A1+A2 is complete in the time interval of 2006–2010; during the same period, Sample B is almost complete: four comets are still observable, one of which, C/2010 U3 Boattini, will pass perihelion in 2019!

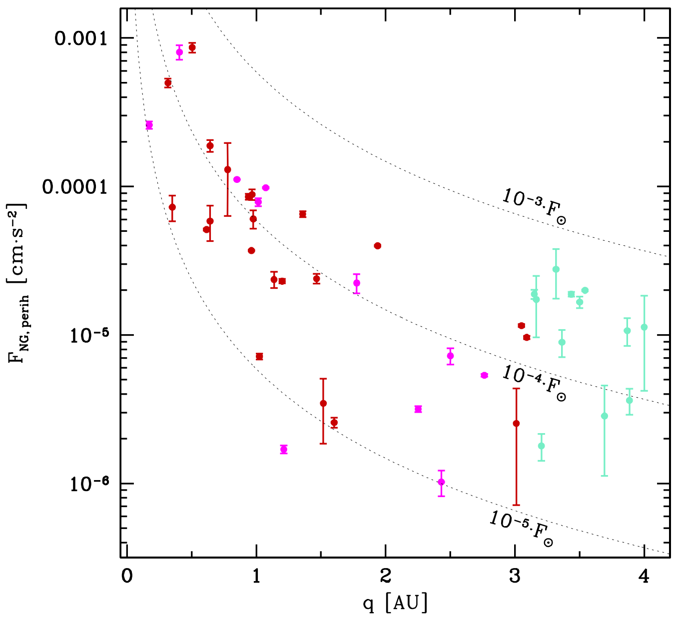

Fig. 1. Maximum NG accelerations, $F_{NG,perih}$, as a function of perihelion distance for all 45 near-parabolic comets with determinable NG effects. Three samples A1, A2 and B are shown by red, magenta and turquoise symbols, respectively. The dotted curves represent the 10^{-5}, 10^{-4} and 10^{-3} of the solar gravitational acceleration $F_{\odot}$, respectively. NG parameters taken for preparation of this plot are in Part II of this catalogue (Table B.4).

3.2. Part I of the catalogue. Characteristics of the observational material

This part of the catalogue consists of one extensive table where the description of observational material is given for each comet including the new quality-class assessment proposed in Paper 4 and briefly described in Sect. 2.2.
The full list of catalogue comets is shown in Table A.1 and is available at `ssdp.cbk.waw.pl/LPCs`.

Table A.1 includes the detailed description of the observational data sets used for osculating orbit determination (Cols. (4–8)), type of the best possible model that can be determined using these data (Col. (9)) and then its quality assessment in the proposed new scheme (Col. (12)). The number of residuals used for orbit determination and resulting rms are given in Col. (13), and Col. (14) informs where this solution was used for dynamical studies.

Since Table A.1 is also focused upon the best/preferred orbit for investigating the dynamical origin of near-parabolic comets, the more dedicated models for this purpose are given whenever it is necessary, that is, when even the NG model based on entire data set not fully satisfies three criteria described in detail in Papers 1–4 (based on rms, O–C-diagram and O–C-distribution). This is indicated by subscript "un" in Col. (9) of Table A.1 (some additional details are given in the notes to this table). Thus, for the cases marked NG_{un} in Col. (9), the better models based on some subsample of data are shown in the next rows for a given comet.

For an unsatisfactory solution based on an entire data set, it was found that the best method is to divide the data set into pre- and post- perihelion subsets to determine the pre-perihelion and post-perihelion osculating orbit for the purpose of past and future dynamical evolution, respectively (as for example for C/2007 W1), or to construct a dedicated subset of data taken at large heliocentric distances from the Sun (as for C/2001 Q4). Then the preferred models for the past/future dynamical evolution are given in the second/third row of a given object in almost all cases where orbital solution based on the entire data seems to be unsatisfactory (except for two comets, C/1990 K1 and C/1993 A1, where a more individual data treatment has not been taken yet; see also notes to Table A.1 for these comets). It is important to note that in these cases the quality assessment may change as, for example, for comet C/2007 W1 or C/2008 A1.

Therefore, the statistics of orbital classes also depends on types of osculating orbits taken into account. Table 3 shows this statistics for the sample of 119 near-parabolic comets for two sets of osculating orbits: the best osculating orbits determined on the basis of an entire interval of data (second column labelled as "standard") and the most preferred orbits for the past dynamical investigation (third column labelled as "past evolution").
The osculating orbits corresponding to all models described in Table A.1 as well as their original and future orbits are given in Parts II, III and IV, respectively.

Table 3. Statistics of orbital quality classes for investigated comets (more details in the text).

Orbital class	Standard	Past evolution
1a+	37	34
1a	46	47
1b	25	26
2a	8	9
2b	2	2
3	1	1

3.2.1. Application of the new scheme of orbital quality assessment

The new quality estimates of the orbits of 119 LPCs are presented in Cols. (10)–(12) of Table A.1.

There is a higher diversification in orbital classes between investigated comets than was found using the original MSE recipe. This can easily be checked by taking the Q^*-values given in Col. (10) or (11) of Table A.1 and using Eq. (4).

In Papers 1–4, the orbit determination is based quite often on a larger data set (in most cases currently available at IAU Minor Planet Center Database 2013) than was used in MWC 08 or at IAU Minor Planet Center Database to obtain the orbital elements given there. Thus, our orbital quality assessment sometimes lists a better quality class than that shown in MWC 08, although our method of quality assessment is more restrictive (see numerous notes appended to Table A.1).

3.2.2. Sample A1. Near-parabolic comets of q_{osc} < 3.1 au discovered before the year 2006

The modified method of orbital quality determination was applied to pure GR as well as to NG orbits of analysed small perihelion comets. All Oort spike comets were chosen from MWC 08 as objects with highest quality orbits (classes 1A or 1B) or with an NG orbit[1].

Table A.1 shows that of the 28 comets of q_{osc} < 3.1 au almost all have determinable NG orbits; C/1992 J1, C/2001 B1, C/2001 K3, C/2002 Q5, C/2003 T3, and C/2005 E2 are six exceptions. We found that six comets from this sample should be classified as second-quality orbit according to new, more restrictive method (see Table 4). Uncertainties of $1/a_{osc}$ are lower than 20 in units of 10^{-6} au^{-1} for five of them (Col. (3) of Table 4), which means that they are significantly poorer than for the remaining comets in this sample. All five have NG orbits, which is a natural consequence because more parameters were used for the orbit determination (six orbital elements plus NG parameters). For the sixth comet, C/2001 K3, only a pure GR orbit was determinable and its second-class quality of osculating orbit is mainly due to a very short time interval.

Additionally, from seven comets with an NG orbit in MWC 08 only three listed in Table 4 have second-quality orbits according to the modified method (applying the original MSE method to our orbit determinations – only two comets). Some comment is needed for C/1952 W1. In Paper 1, we determined an osculating orbit from 36 positional observations taken from the literature[2]. This is in fact the only comet, for which we had determined the orbit on the basis of fewer measurements than in the MWC 08; for more details see Paper 1. Thus, the MWC 08 describes an orbit of C/1952 W1 as 1B class (64 observations, the data interval is the same as ours), whereas using the MSE method for our orbit determination we obtain class 2A (Cols. 2 and 3 of Table 4).

According to the more restrictive orbital quality assessment in the sample of 28 comets we obtained 8 comets of class 1a+, 4 comets of class 1a, 10 of class 1b, 5 of class 2a, and 1 object of class 2b in this sample.

3.2.3. Sample A2. Near-parabolic comets of q_{osc} < 3.1 discovered in the years 2006–2010

In Paper 4 we selected all near-parabolic comets discovered in the years 2006–2010 that have small perihelion distances, q_{osc} < 3.1 au, and $1/a_{ori}$ < 0.000150 au^{-1}. According to the proposed method of orbital quality assessment we have in this sample a lower fraction of comets of the best orbital classes: 11 instead of 15 derived using the MSE quality system. Additionally, these 11 comets are now divided into five comets of class 1a+ and six comets of class 1a using the entire data sets shown in Table A.1 in the first row of a given object. Moreover, the orbit of one comet, C/2008 C1, is reclassified as a second-class orbit. For more details see Paper 4.

3.2.4. Sample B. Near-parabolic comets of q_{osc} ≥ 3.1 au discovered in the period 1970–2010

In the sample of comets with large perihelion distances, the lowest value of Q^* (Eq. (4)) is 6.0 for two comets, C/2006 YC and C/2007 Y1 (Table 5). Therefore, orbits of these two comets should be classified as second quality (2a class), according to our more restrictive method. In MWC 08, both orbits were classified as class 2A probably because of the very short intervals of observations, two months for C/2006 YC and 2.5 months for C/2007 Y1 (Col. 2 of Table 5). The current orbits of these two comets are based on almost periods of data twice as long, 4 and 4.5 months, respectively, which resulted in improving the quality of orbits from second to first class when using the MSE method of quality assessment (Col. 3 of Table 5). For this reason, these two comets were also investigated by us in Paper 2.

Three comets with greatest $1/a_{osc}$ uncertainties in this sample, C/1978 G2 (37.9×10^{-6} au^{-1}), C/1983 O1 (20.5×10^{-6} au^{-1}) and C/1976 U1 (21.5×10^{-6} au^{-1}), now have class 1b, 1a, 1b (1B, 1A and 1B in MWC 08), respectively, because of the relatively long time interval of data. C/1983 O1 stands out among them because of the longest data interval (7.5 years) and the closest perihelion distance of 3.3 au to the Sun, which allowed determining the NG orbit (Paper 2). The remaining two comets have q_{osc} > 5.5 au, so any NG traces in the motion, and data intervals shorter than two years. In general, the NG orbit (if determinable) seems to be closer to the actual motion of a given comet than the pure GR orbit, but when the NG parameters are included in the orbit determinations this can result in significantly grater uncertainties of orbital elements than for the pure GR orbit. This is the case of C/1983 O1, where the uncertainty of $1/a$ determination of NG orbit is one order of magnitude larger (20.5×10^{-6} au^{-1}) than for GR orbit (1.5×10^{-6} au^{-1}). When NG orbits, although they are more realistic than pure GR orbits, are characterized by significantly larger uncertainties of orbital elements than GR orbits, then the second parameter of orbital quality assessment, the time interval of data, plays an important role, as for C/1983 O1.

[1] The quality orbit assessment of near-parabolic comets with NG orbits is not given in MWC 08.

[2] At the IAU Minor Planet Center Database (2013) only six observations are available.

Table 4. Comets of class 1A or 1B or NG orbits according to MWC 08 and with orbital quality poorer than first class according to the proposed, modified classification of orbit quality for 28 small-perihelion comets ($q_{osc} < 3.1$ au).

Comet	Quality of orbit MSE method MWC 08 class	MSE method applied to our orbits Q (Eq. (3)), class	Modified method applied to our orbits Q^*, Q(Eq. (4)), class	$1/a_{osc}$-uncertainty in units of [10^{-6} au^{-1}] our analysis	Data interval [months]	References
(1)	(2)	(3)	(4)	(5)	(6)	(7)
C/1885 X1	NG orbit	7, 1B	6.0, 6.0, 2a	36.1	4.7	Paper 1
C/1892 Q1	1B	7, 1B	6.0, 6.0, 2a	26.2	10.4	Paper 1
C/1952 W1	1B	6, 2A	5.5, 6.0, 2a	187.5	7.3	Paper 1
C/1959 Y1	NG orbit	6, 2A	5.0, 5.0, 2b	101.5	5.5	Paper 1
C/1989 Q1	NG orbit	6, 2A	5.5, 6.0, 2a	25.9	4.1	Paper 1
C/2001 K3	1B	7, 1B	6.0, 6.0, 2a	6.8	4.8 (3.0)	Paper 2

Notes. Orbital class is not specified in MWC 08 for comets with NG orbit given there; in Col. (6) the number in parentheses shows a shorter time interval of data available when completing MWC 08.

Table 5. Same as in Table 4 for large-perihelion comets ($q_{osc} \geq 3.1$ au).

Comet	Quality of orbit MSE method MWC 08 class	MSE method applied to our orbits Q (Eq. (3)), class	Modified method applied to our orbits Q^*, Q(Eq. (4)), class	$1/a_{osc}$-uncertainty in units of [10^{-6} au^{-1}] our analysis	Data interval [months]	References
(1)	(2)	(3)	(4)	(5)	(6)	(7)
C/2006 YC	2A	7, 1B	6.0, 6.0, 2a	12.3	4.0 (2.0)	Paper 2
C/2007 Y1	2A	7, 1B	6.0, 6.0, 2a	12.4	4.6 (2.5)	Paper 2

Notes. Orbital class is not specified in MWC 08 for comets with NG orbit given there; in Col. (6) the number in parenthesis shows a shorter time interval of data available when completing MWC 08.

According to our new orbital quality assessment, we obtained 24 comets of class 1a+, 36 comets of class 1a, 7 of class 1b, and 2 objects of class 2a in sample B.

3.3. Part II of the catalogue. Osculating orbital elements

This part of the catalogue consists of three tables (Tables B.1–B.3) including samples A1, A2 and B, respectively. Each of them contains the comet designation and its name (Col. (1)), epoch (osculation date, Col. (3)) and the six heliocentric orbital elements usually given for comets (Cols. (3)–(9)), that is, perihelion time (TT), perihelion distance (in astronomical units), eccentricity, argument of perihelion (in degrees, equinox 2000.0), longitude of ascending node (in degrees, equinox 2000.0), and inclination (in degrees, equinox 2000.0). Additionally, the inverse semi-major axis is presented in Col. (9).

The astrometric data sets used for each orbital solution determination are presented in Part I of the catalogue (Table A.1).

The NG parameters for all NG osculating orbits included in the catalogue (i.e. for 45 comets, see Table A.1) are shown in the separate Table B.4. Most comets from sample A1 have NG orbits (almost 80 per cent). These NG solutions are characterized by a clear decrease in rms compared with the rms for purely GR orbits, only for C/1974 F1 this decrease is infinitesimal. Sample A2 includes 11 osculating NG orbits, thus 50 per cent of comets discovered in the period of 2006–2010 with a small perihelion distance ($q_{osc} < 3.1$ au) have determinable NG effects in their motion. On the other hand, only 12 of 69 comets of sample B have NG orbits. For some comets even NG orbits exhibit some trends in O−C time variations. In these peculiar cases the second and sometimes the third orbital solutions are presented. Additional orbits are based on some subsamples of data, as described in Table A.1 (see also Sect. 3.2). These dedicated solutions are more appropriate for studying the origin and/or future evolution of the cometary orbit.

3.4. Part III of the catalogue. Original orbital elements

Similarly as in Part II, three tables (Tables C.1, C.2, and C.3) corresponding to samples A1, A2, and B are presented here. Each of them contains the original barycentric orbits calculated at the distance of 250 au from the Sun. Tables have an analogous structure and entries to those in Part II.

To derive the original and future inverse semi-major axis, the dynamical calculations of a swarm of VCs of each individual objects were performed backwards and forwards in time until it reached 250 au from the Sun, that is, at a distance where the planetary perturbations are already completely negligible. Each individual swarm of starting osculating orbits consists of 5001 VCs including the nominal orbit and was constructed according to a Monte Carlo method proposed by Sitarski (1998), where the entire swarm fulfilled the Gaussian statistics of fitting to positional data used for a given osculating (nominal) orbit determination. This method allowed us to determine the uncertainties of original and future orbital elements, including the inverse semi-major axes by fitting each orbital element of original/future swarm of VCs to Gaussian distribution (see Tables C.1–D.3).

The distribution of $1/a_{ori}$ based on the best solutions derived from past dynamical studies and incorporating the uncertainties of $1/a_{ori}$ determinations is shown in Fig. 2. The only object from the sample of 119 comets seems to be a serious candidate to interstellar comet (C/2007 W1 Boattini, for more details see Paper 4). The left and negative wing of the main distribution

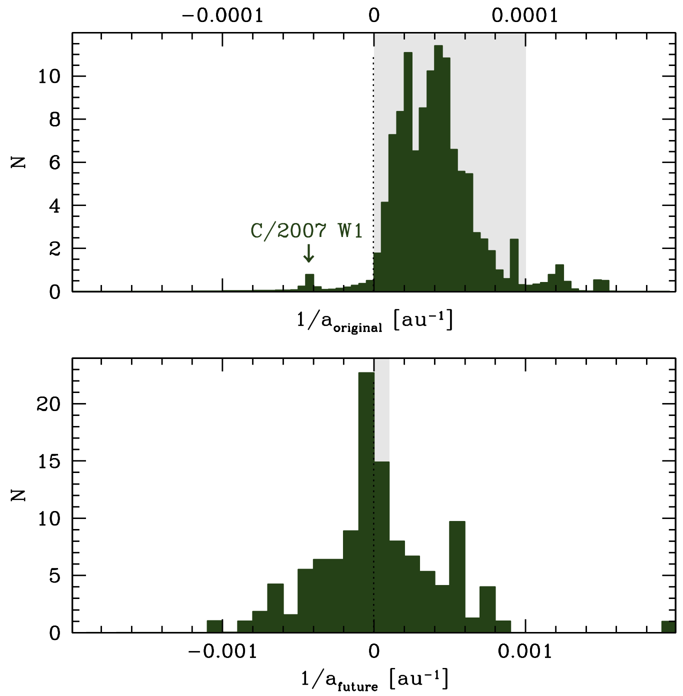

Fig. 2. Distribution of $1/a_{ori}$ (*upper panel*), $1/a_{fut}$ (*lower panel*) for 119 considered LPCs. The uncertainties of $1/a$ determinations were incorporated into these $1/a$ histograms by taking the full cloud of VCs for each comet. This means that both distributions are composed of 119 individual normalized 1/a distributions resulting from the dynamical calculations of 5001 VCs.

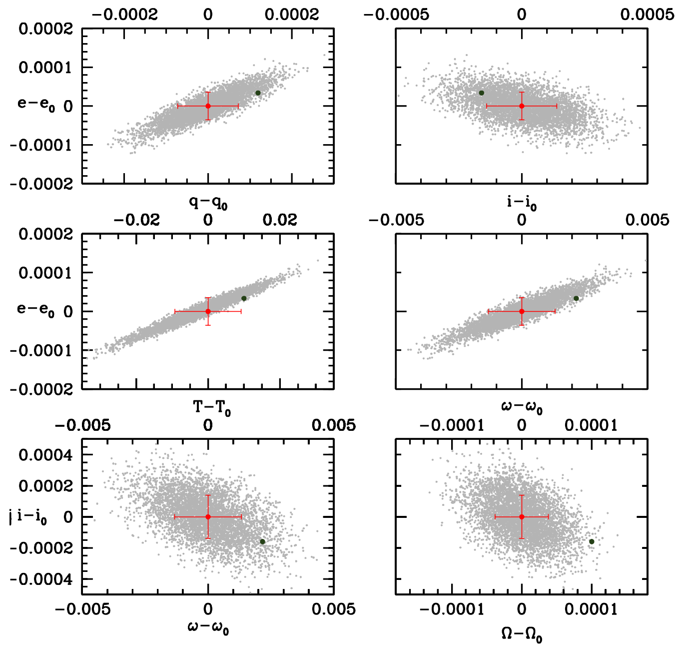

Fig. 3. Projection of the 6D space of 5 001 VCs of C/1988 B1 onto six chosen planes of osculating orbital elements. Vertical axes given in the *right-hand panels* are exactly the same as the vertical axes in the *left-hand panels*. Each grey point represents a single virtual orbit, while the large red point represents the nominal orbit solution given here and the green point is taken from MWC 08 (see also Table 6). Each plot is centred on the nominal values of the respective pair of osculating orbital elements denoted by the subscript "0"; see also Table 6.

is formed by a few comets with rather broad individual $1/a_{ori}$ distributions (Gaussians), such as C/1978 G2 (see Table C.3) with a formally negative, but poorly known, inverse semi-major axis of -22.4 ± 37.8 in units of 10^{-6} au^{-1}, or by C/1984 W2 with $1/a_{ori} = 36.1 \pm 20.2$ in the same units. The main peak of $1/a_{ori}$ is broad and extends between 10 and 65 in units of 10^{-6} au^{-1} (a_{ori}: ~15 400–100 000 au). More precisely, the calculated 10 and 90 per cent deciles are 11.5 and 74.5 in units of 10^{-6} au^{-1}, respectively. The median value of the $1/a_{ori}$ distribution is 37.95×10^{-6} au^{-1} ($a_{ori} \simeq 26\,300$ au). The main part of $1/a_{ori}$ distribution seems to have a local minimum somewhere between 25–35 in units of 10^{-6} au^{-1}, but the histogram based on twice wider bins gives a broad single maximum. This dip in broad Oort maximum is exclusively caused by large-perihelion comets. Thus, significantly richer statistics are needed to confirm or refute the double nature of this maximum.

3.5. Part IV of the catalogue. Future orbital elements

This part consists of Tables D.1–D.3 (samples A1, A2, B) giving future barycentric orbits calculated at a distance of 250 au from the Sun.

The $1/a_{fut}$ distribution constructed from the future orbits presented in these tables are shown in the lower panel of Fig. 2. Fifteen comets (~13 per cent of the sample) have a future inverse semi-major axis within the same range of $0 < 1/a_{fut} < 100 \times 10^{-6}$ au^{-1} where the original 1/a distribution is placed, ~51 per cent of comets leave the solar system on hyperbolic orbits, and about 36 per cent of objects have evolved into more tightly bound orbits under the influence of planetary perturbations. The narrow peak in the range $|1/a_{fut}| < 100 \times 10^{-6}$ au^{-1} is evident and includes more than 30 per cent of the entire sample. This peak mostly consists of comets with large perihelion distances ($q_{osc} > 3.1$ au), which means that these comets reproduced 78.5 per cent of the peak, whereas the entire sample of 118 objects taken for this statistics (comet C/2010 X1 Elenin disintegrated shortly after perihelion passage) includes only 69 large-perihelion comets (58 per cent of the sample).

4. Concluding remarks

4.1. About accuracy

In this catalogue great care was taken to treat the data completely homogeneously together with an individual approach to determining NG effects wherever it seemed necessary. In Papers 1–2 it was shown that data treatment is crucial for an orbit determination of one-apparition comets and the applied methods of data selection and weighting are there discussed in details. An individual approach was applied when there were any doubts about the O−C time variation of residuals or the O−C distribution of residuals (for the standard model based on the all available data). Thus, sometimes two sets of osculating orbits are offered for a given comet, in particular, for some comets with determinable NG effects. In these cases, the first set always gives the overall model of NG motion derived using the entire set of data. The second set describes the orbit derived using a subset of data, e.g. using only the pre-perihelion data for ingoing leg of orbit, and post-perihelion data for outgoing leg of orbit, respectively (see for example the case of C/2007 T2 or C/2008 A1). This approach was necessary because of the simplicity of the NG model used for orbital calculations (usually three constant NG parameters, see Table B.4). In fact, it was the only possible model for the purpose of such a massive NG determination in the motion of LPCs. A detailed discussion of the different forms of NG accelerations is given in Paper 3 for the two small-perihelion comets

Table 6. Heliocentric orbital elements of osculating orbits for comets C/1988 B1 Shoemaker and C/2002 J4 NEAT (Sample B, see also Table A.1).

	Epoch	T_0	q_0	e_0	ω_0	Ω_0	i_0	$1/a_{\rm ori,0}$	References
				Comet C/1988 B1 Shoemaker					
$\rm elem_{nom,i}$	19870326	19870320.107555	5.03070649	1.00248504	124.217043	325.159660	80.585940	20.0	here
δ_i		±.009206	±.00007222	±.00003544	±.001331	±.000038	±.000139	±7.0	
$\rm elem_{cat,i}$	19870326	19870320.12030	5.0308257	1.0025188	124.21921	325.15976	80.58578	13	MWC 08
$\rm Diff_i$		0.98	1.17	0.67	1.15	1.86	0.81	0.71	
				Comet C/2002 J4 NEAT					
$\rm elem_{nom,i}$	20031008	20031003.151072	3.63378023	1.00001831	230.705722	70.881227	46.521834	33.9	here
δ_i		±.000235	±.00000105	±.00000356	±.000035	±.000014	±.000015	±1.0	
$\rm elem_{cat,i}$	20031008	20031003.15132	3.6337804	1.0000199	230.70575	70.88122	46.52183	35	MPC 75513
$\rm Diff_i$		0.75	0.11	0.45	0.57	0.35	0.19	0.78	

Notes. The successive columns signify (2) epoch, i.e. osculation date, (3) perihelion time [TT], (4) perihelion distance, (5) eccentricity, (6) argument of perihelion (in degrees), equinox 2000.0, (7) longitude of the ascending node (in degrees), equinox 2000.0, (8) inclination (in degrees), equinox 2000.0. In the last line we present for each comet the difference between the nominal and catalogue values of a given element divided by the respective combined error, thus $\rm Diff_i = elem_{nom,i} - elem_{cat,i}/(\sqrt{2}\delta_i)$.

C/2001 Q4 and C/2007 T2. In that paper, we showed that determining the exponents for the $g(r)$-like function is very difficult and, in practice, this was only possible for these two particular comets from the catalogue sample.

An additional note is needed for large-perihelion comets with NG orbits in the catalogue. The $g(r)$-form of NG accelerations used here describes the water ice sublimation. Thus, this relationship is very coarse for comets with large perihelion distances, where the percentage of the more volatile ices may be relatively high.

In the context of this discussion, we strongly emphasize that all the uncertainties of osculating orbital elements given in the catalogue tables (and hence the uncertainties of original and future orbits) represent the formal errors derived by fitting the assumed model of motion (GR or NG) to positional observations. If it were possible to explore the NG acceleration along the orbit of a given comet more precisely, the solution might be different. How different depends on the case in question. However, as was shown in Paper 3, the scatter of $1/a_{\rm ori}$ values for various NG models appears to be significantly smaller than the difference between the $1/a$-values between the pure GR and the standard NG model for the two comets examined there. Therefore, it seems that this relatively simple type of model of NG acceleration applied for the purpose of this catalogue gives orbits that are significantly closer to the actual past and future motion of analysed comets. When the various NG orbits are given in the catalogue, a more cautious approach to the formal errors is necessary. For this reason, in the case of comet C/2007 W1 Boattini, which is the best candidate for a comet on an original hyperbolic orbit, the various NG models were taken into account (see Paper 4) to be conclusive about the shape of its barycentric original orbits. We concluded in Paper 4 that all of them indicate that this comet moved on a barycentric hyperbolic orbit before entered the planetary zone. This makes this comet the best candidate to have an interstellar origin among the catalogue comets.

Generally, the GR orbits given in this catalogue differ from the solutions given in MWC 08 or IAU Minor Planet Center Database (2013) by no more than 3σ-error for each orbital element; typically by even less than a 2σ-error. Two representative examples are given in Table 6 for comets C/1988 B1 and C/2002 J4, which have 1a and 1a+ quality class orbit, respectively. Both solutions are based on the data span over long time intervals (more than 4 yr). In the last line for each comet in Table 6 the difference in each orbital element is expressed as combined errors and assuming the same orbital element uncertainties for the solution given in MWC 08 (IAU Minor Planet Center Database 2013) as derived here. Additionally, for C/1988 B1, the solution taken from MWC 08 is compared in Fig. 3 with the swarm of osculating VCs derived for the past and future evolutionary calculations. Orbit of C/1988 B1 given in MWC 08 was determined using 112 residuals (rms = 1.″00), whereas the orbit presented here was obtained on the basis of 127 residuals (rms = 0.″98, without weighting of the data).

An extensive discussion of possible differences of the NG solutions given in this catalogue from other published results is presented in Paper 4 for two comets with variable NG effects, C/2007 W1 and C/2008 A1.

For comets with two different NG solutions given in this catalogue, both orbits can be taken by the user to investigate a cometary activity within the observational interval. However, for long-time orbital calculations, the more dedicated orbit is recommended, for example to investigate the cometary origin, the orbit determined using the pre-perihelion data should be taken into account.

The web catalogue also offers the swarms of original and future VCs, that is, the barycentric orbital elements at the distances where planetary perturbations are negligible for all models from Table 2. Thus, the swarms of original and future NG orbits are also available in this catalogue for further investigation by the user.

4.2. Future plans

This catalogue will be supplemented in the future by the sample of one-apparition comets discovered in the first half of the twentieth century. Orbits of such old comets particularly need to be redetermined because they were originally obtained using very different numerical methods and assumptions on the model of the solar system, including the number of planets taken into account. The first part of this long-standing project describing the analysis of 38 comets from the Oort spike will soon be submitted for publication.

One of the issues awaiting for extensive numerical tests is whether the gravitational influence of the mass of the asteroid belt, Kuiper Belt, and Oort Cloud will have a strong effect in particular cases on the orbital elements of near-parabolic comets that general move on steeply inclined orbits to the ecliptic plane.

Some test were made for the most massive bodies from the Main Belt (which seems to be the more important agent for the comets investigated here), and no important orbital changes were so far noticed for a few exercised comets. The uncertainties of orbital elements were more than two orders of magnitude greater than the differences in nominal orbit determined using the standard solar system model and that taking into account four massive asteroids from the Main Belt. However, without more scrupulous testing one cannot rule out the rare possibility that a particular comet will be sensitive to perturbations coming from one of the relatively massive bodies (due to close encounter). In the future it will be potentially interesting to incorporate the many massive minor planets into the dynamical model of the solar system and perform such tests for all comets with previously determined orbits. Additionally, it is not obvious how the global mass distribution of mentioned three populations of solar system minor bodies are gravitationally important for near-parabolic comets. These plans of comprehensive tests will be gradually put into practice.

Acknowledgements. I wish to thank the reviewer Luke Dones for many constructive suggestions that improved this paper. The orbital calculation was performed using the numerical orbital package developed by Professor Grzegorz Sitarski and the Solar System Dynamics and Planetology Group at SRC PAS.

References

Dybczyński, P. A., & Królikowska, M. 2011, MNRAS, 416, 51 (Paper 2)
IAU Minor Planet Center 2013, MPC Database Search, http://www.minorplanetcenter.net/db_search/
IAU Minor Planet Center 2013, Uncertainty Parameter U and Orbit Quality Codes, http://www.minorplanetcenter.net/iau/info/UValue.html
JPL Small-Body Database Browser, 2013, JPL Database Search, http://ssd.jpl.nasa.gov/sbdb.cgi
Królikowska, M. 2006, Acta Astron., 56, 385
Królikowska, M., & Dybczyński, P. A. 2010, MNRAS, 404, 1886 (Paper 1)
Królikowska, M., & Dybczyński, P. A. 2013, MNRAS, 435, 440 (Paper 4)
Królikowska, M., Dybczyński, P. A., & Sitarski, G. 2012, A&A, 544, A119 (Paper 3)
Marsden, B. G., & Williams, G. V. 2008, Catalogue of Cometary Orbits, 17th edn. (Cambridge, MA: Smithsonian Astrophysical Observatory)
Marsden B. G., Sekanina, Z., & Yeomans, D. K. 1973, AJ, 78, 211
Marsden, B. G., Sekanina, Z., & Everhart, E. 1978, AJ, 83, 64
Nakano, S. 2009a, Nakano Note 1731a, available at http://www.oaa.gr.jp/~oaacs/nk1731a.htm
Nakano, S. 2009b, Nakano Note 1731b, available at http://www.oaa.gr.jp/~oaacs/nk1731b.htm
Nakano, S. 2009c, Nakano Note 1807, available at http://www.oaa.gr.jp/~oaacs/nk1807.htm
Sitarski, G. 1989, Acta Astron., 39, 345
Sitarski, G. 1998, Acta Astron., 48, 547
Sitarski, G. 2002, Acta Astron., 52, 471

Appendix A: Part I. Description of observational material and orbital quality assessment

Table A.1. Characteristics of observational material and the new quality assessment for 119 near-parabolic comets investigated in Papers 1–4 (see references in the last col.).

Comet name	q_{osc} [au]	T [yyyymmdd]	Observational arc dates [yyyymmdd–yyyymmdd]	No of obs	Data arc span [yr]	Heliocentric distance span [au]	Data type	Type of model	Q^* GR model	Q^* NG model	New orbital class	rms [arcsec] /no of res.	Ref & Notes
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Sample A1. Years 1885–2005. 28 near-parabolic comets of $q_{osc} < 3.1$ au $1/a_{ori} < 150 \times 10^{-6}$ au^{-1}													
C/1885 X1 Fabry	0.642	18860406	18851201–18860719	228	.63	2.29–2.00	full	NG	6.5	6.0	2a	3.58/ 390	P1,1
C/1892 Q1 Brooks	0.976	18921228	18920901–18930713	191	.85	2.11–3.04	full	NG	6.5	6.0	2a	2.80/ 334	P1,1
C/1952 W1 Mrkos	0.778	19530124	19521210–19530718	36	.60	1.16–2.86	full	NG	6.0	5.5	2a	1.08/ 61	P1,2
C/1956 R1 Arend-Roland	0.316	19570408	19561108–19580411	249	1.4	2.83–5.36	full	NG	7.0	7.0	1b	1.39/ 458	P1,1
C/1959 Y1 Burnham	0.504	19600320	19600104–19600617	88	.45	1.63–1.81	full	NG	6.0	5.0	2b	1.60/ 146	P1,1
C/1974 F1 Lovas	3.011	19750822	19740321–19770911	137	3.5	5.64–7.26	full	NG	8.0	8.0	1a	1.08/ 273	P2
C/1978 H1 Meier	1.137	19781111	19780428–19791209	287	1.6	3.00–5.02	full	NG	7.5	7.0	1b	1.00/ 565	P1,1
C/1986 P1-A Wilson	1.200	19870420	19860805–19890411	688	2.7	3.64–7.83	full	NG	8.5	8.0	1a	1.11/1361	P1
C/1989 Q1 Okazaki-Levy-Rudenko	0.642	19891111	19890824–19891224	231	.33	1.63–1.08	pre+	NG	6.0	5.5	2a	1.30/ 452	P1,1
C/1989 X1 Austin	0.350	19900409	19891206–19900627	281	.56	2.44–1.74	full	NG	7.0	6.5	1b	1.28/ 537	P1,1
C/1990 K1 Levy	0.939	19901024	19900521–19920401	678	1.9	2.57–6.36	full	NG_{un}	7.5	7.0	1b	0.95/1321	new,1
C/1991 F2 Helin-Lawrence	1.518	19920120	19910223–19920930	114	1.6	4.25–3.52	full	NG	7.5	7.0	1b	0.78/ 213	P1
C/1992 J1 Spacewatch	3.007	19930905	19920501–19950202	248	2.8	5.46–5.61	full	GR	8.5	–	1a+	0.78/ 494	P2,1
C/1993 A1 Mueller	1.938	19940112	19921126–19940817	746	1.4	4.89–3.19	pre+	NG_{un}	7.5	7.5	1a	0.87/1483	new,1
C/1993 Q1 Mueller	0.967	19940326	19930816–19940417	526	1.5	3.33–1.04	pre++	NG	7.5	7.0	1b	0.92/1041	P1,1
C/1996 E1 NEAT	1.359	19960727	19960315–19961012	249	.58	2.31–1.76	pre+	NG	7.0	7.0	1b	0.60/ 492	P1
C/1997 J2 Meunier-Dupouy	3.051	19980310	19970505–19991009	1446	2.4	4.24–6.06	full	NG	8.5	8.5	1a+	0.53/2863	P1,P2
C/1999 Y1 LINEAR	3.091	20010324	19991029–20030719	884	3.7	5.60–7.91	full	NG	8.5	8.5	1a+	0.48/1749	P1,P2,1
C/2001 B1 LINEAR	2.928	20000919	20010122–20020108	162	.96	3.18–5.34	post!	GR	7.0	–	1b	0.56/ 317	new
C/2001 K3 Skiff	3.060	20010422	20010522–20011012	346	.39	3.07–3.49	post	GR	6.0	–	2a	0.67/ 669	P2,1
C/2001 Q4 NEAT	0.962	20040515	20010824–20060818	2681	5.0	10.1–8.82	full	NG_{un}	9.0	9.0	1a+	0.56/5316	P3
				1518	5.0	10.1–8.82		DIST	8.5	8.5	1a+	0.52/3012	P3
C/2002 E2 Snyder-Murakami	1.466	20020221	20020308–20030108	941	.83	1.48–4.18	post	NG	7.0	7.0	1b	0.57/1863	P1,1

Notes. The sample includes comets with first-quality orbits or NG orbits in MWC 08 and those discovered during the years 2006–2010. The observational material of comets taken for osculating orbit determination is described in Cols. (2)–(8) and (13), whereas the new orbit quality assessment resulting from the osculating orbit based on these data sets is shown in Cols. (10)–(12). The second and third columns show an osculating perihelion distance and perihelion time. The data distribution relative to a perihelion passage is presented in Cols. (7) and (8), where "pre!" ("post!") means that all observations were taken before (after) perihelion passage; "pre+" ("post+") means that significantly more pre-perihelion (post-perihelion) measurements were available, and an additional "+" indicates the drastic dominance of pre-perihelion (post-perihelion) measurements in both the number and the time interval. Column (9) shows the type of the best model possible to determine from the full interval of data, where the subscript "un" indicates that the GR and even the NG model determined from the entire interval of data are not satisfactory in the sense of the three criteria described in detail in Papers 1–4. For such an unsatisfactory orbital solution the better model for pre-perihelion motion (that based on some subsample of data) is given in the second line of a given comet, except for comets C/1990 K1 and C/1993 A1, where no individual data treatment has been applied yet. Columns (10) and (11) give the Q^* for GR and NG models, respectively. The orbital class resulting from the model described in Col. (9) and determined according to the new quality assessment is given in Col. (12). References to publications in which dynamical studies were based on the orbital solution presented here are listed in the last column, where P1 refers to Królikowska & Dybczyński (2010), P2 to Dybczyński & Królikowska (2011), P3 to Królikowska et al. (2012), and P4 to Królikowska & Dybczyński (2013). Many additional notes to individual objects are appended to this table, and the remark "new" indicates solutions that have not been used in P1–P4. Notes in Col. (14): [(1)] many more observations were used here than were used for the MWC 08 orbit or the orbit given at the IAU Minor Planet Center Database (2013) (as of May 2013). [(2)] Significantly fewer observations of C/1952 W1 was available for us than were used for the MWC 08 orbit determination. [(3)] This new solution is based on a data interval three days longer and containing 4 more observations than the orbit analysed in Paper 2. [(4)] Orbit is based on a data interval ~8.5 months longer and containing 3 more observations than that analysed in Paper 2. [(5)] Orbit is based on a data interval ~3 weeks longer and containing 4 more observations than that analysed in Paper 2. [(6)] Orbit is based on a data interval ~1.6 yr longer and containing 4 more observations than that analysed in Paper 2; this results in an increase from quality class 1a to 1a+. [(7)] Orbit is based on a data interval ~two months longer and containing 9 more observations than that analysed in Paper 2. [(8)] Orbit is based on a data interval ~two months longer and containing 2 more observations than that analysed in Paper 2.

Table A.1. continued.

Comet name	q_{osc}	T	Observational arc dates	No of obs	Data arc span	Heliocentric distance span	Data type	Type of model	Q^*		New orbital class	rms [arcsec] /no of res.	Ref & Notes
	[au]	[yyyymmdd]	[yyyymmdd–yyyymmdd]		[yr]	[au]			GR model	NG model			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
C/2002 Q5 LINEAR	1.243	20021119	20020828–20030530	609	.75	1.75–2.92	full	NG	7.0	–	1b	0.62/1178	new
C/2002 T7 LINEAR	0.615	20040423	20021012–20060320	4507	3.4	6.91–8.08	full	NG_{un}	8.5	8.5	1a+	0.50/8878	P3
			20021012–20040417	3655	1.5	6.91–0.63		PRE	–	8.0	1a	0.36/7170	P3
			20040424–20060320	848	1.9	0.62–8.08		POST	–	7.0	1b	0.49/1659	new
C/2003 K4 LINEAR	1.024	20041013	20030528–20061117	3658	3.5	6.11–8.30	full	NG_{un}	8.5	8.5	1a+	0.46/7245	new,1
			20030528–20061117	1838	3.5	6.11–8.30		DIST	8.0	8.0	1a+	0.44/3632	new
C/2003 T3 Tabur	1.48	20040429	20031014–20050503	749	1.6	2.96–4.63	full	GR	8.0	–	1a	0.60/1512	new
C/2004 B1 LINEAR	1.602	20060207	20040128–20080824	2057	4.6	7.74–9.15	full	NG	9.0	9.0	1a+	0.43/3758	P1,1
C/2005 E2 McNaught	1.520	20060223	20050312–20080303	1364	3.0	4.42–7.76	full	GR	8.5	(8.0)	1a+	0.43/ 266	new
Sample A2. Years 2006–2010. Complete sample of near-parabolic comets of $q_{osc} < 3.1$ au and $1/a_{ori} < 150 \times 10^{-6}$ au^{-1}													
C/2006 HW_{51} Siding Spring	2.266	20060929	20060423–20070807	187	1.3	2.87–4.04	full	GR	7.5		1a	0.29/ 356	P4
C/2006 K3 McNaught	2.501	20070313	20060522–20080126	207	1.7	3.95–4.13	pre+	NG	7.5	7.5	1a	0.54/ 402	P4
C/2006 L2 McNaught	1.994	20061120	20060614–20070707	408	1.1	2.74–3.31	full	GR	7.5		1a	0.49/ 794	P4
C/2006 OF_2 Broughton	2.431	20080915	20060623–20100511	4917	3.9	7.88–6.31	full	NG	8.5	8.5	1a+	0.36/9659	P4
C/2006 P1 McNaught	0.171	20070112	20060807–20070711	341	.93	2.74–3.34	full	NG	6.5	6.5	1b	0.25/ 641	P4
C/2006 Q1 McNaught	2.764	20080703	20060820–20101017	2744	4.2	6.83–7.91	full	NG	9.0	9.0	1a+	0.37/5367	P4
C/2006 VZ_{13} LINEAR	1.015	20070810	20061113–20070814	1173	.73	3.84–1.02	pre++	NG_{un}	6.5	6.5	1b	0.51/2227	P4
			20061113–20070630	419	.63	3.84–1.23		PRE		6.0	2a	0.39/ 823	P4,1
C/2007 N3 Lulin	1.212	20090110	20070711–20110101	3951	3.2	6.38–7.83	full	NG_{un}	8.5	8.5	1a+	0.35/7740	P4
			20070711–20090108	1594	1.5	6.38–1.21		PRE	8.0	–	1a	0.33/3132	P4
			20090428–20110101	515	1.7	2.00–7.83		POST	7.5	–	1a	0.38/1004	P4
C/2007 O1 LINEAR	2.877	20070603	20060402–20071113	183	1.6	4.99–2.91	post++	GR	7.5	–	1a	0.47/ 336	P4
C/2007 Q1 Garradd	3.006	20061211	20070821–20070914	43	24d	3.88–4.02	post!	GR	3.5	–	3a	0.58/ 84	P4
C/2007 Q3 Siding Spring	2.252	20091007	20070825–20110925	1368	4.0	7.64–7.24	full	NG_{un}	9.0	9.0	1a+	0.39/2658	P4
			20070825–20091003	568	2.1	7.64–2.25		PRE	8.5	–	1a+	0.30/1112	P4
			20100608–20111003	177	1.3	3.50–7.24		POST	7.5	–	1a	0.66/ 342	P4
C/2007 W1 Boattini	0.850	20080624	20071120–20081217	1703	1.2	3.33–2.84	full	NG_{un}	7.5	7.5	1a	0.60/3293	new
			20071120–20080612	926	.56	3.33–0.88		PRE		7.0	1b	0.49/1771	P4
			20080630–20081217	777	.47	0.86–2.84		POST		5.5	2a	0.59/1522	P4
C/2007 W3 LINEAR	1.776	20080602	20071129–20080908	212	0.8	2.89–2.17	pre+	NG	6.5	6.5	1b	0.52/ 413	P4
C/2008 A1 McNaught	1.073	20080929	20080110–20100117	937	2.0	3.73–5.82	full	NG_{un}	8.0	8.0	1a	0.44/1852	P4
			20080110–20080928	393	.72	3.73–1.07		PRE		6.5	1b	0.28/ 770	P4
			20081001–20100117	554	1.3	1.07–5.82		POST		6.5	1b	0.54/1072	P4
C/2008 C1 Chen-Gao	1.262	20080416	20080130–20080528	815	0.3	1.71–1.41	pre++	GR	6.0	–	2a	0.36/1544	P4,1
C/2008 J6 Hill	2.002	20080410	20080514–20081207	390	0.6	2.04–3.41	post!	GR	7.0	–	1b	0.47/ 751	P4
C/2008 T2 Cardinal	1.202	20090613	20081001–20090909	1345	0.9	3.60–1.78	pre+	GR	7.0	–	1b	0.38/2609	P4
C/2009 K5 McNaught	1.422	20100430	20090527–20111028	2539	2.4	4.35–6.25	full	GR_{un}	8.5	–	1a+	0.47/4952	P4
			20090527–20100429	820	.92	4.35–1.42		PRE	7.5	–	1a	0.33/1559	P4
			20100430–20111028	1719	1.5	1.42–6.25		POST	8.0	–	1a	0.47/3357	P4
C/2009 O4 Hill	2.564	20100101	20090730–20091214	785	.38	3.04–2.57	pre!	GR	6.5	–	1b	0.39/1522	P4
C/2009 R1 McNaught	0.405	20100702	20090720–20100629	792	.94	5.06–0.41	pre!	NG	7.0	7.0	1b	0.51/1501	P4
C/2010 H1 Garradd	2.745	20100618	20100219–20100702	47	.36	2.82–2.75	full	GR	5.0	–	2b	0.79/ 95	P4

Table A.1. continued.

Comet name (1)	q_{osc} [au] (2)	T [yyyymmdd] (3)	Observational arc dates [yyyymmdd–yyyymmdd] (4)	No of obs (5)	Data arc span [yr] (6)	Heliocentric distance span [au] (7)	Data type (8)	Type of model (9)	Q^* GR model (10)	Q^* NG model (11)	New orbital class (12)	rms [arcsec] /no of res. (13)	Ref & Notes (14)
C/2010 X1 Elenin	0.482	20110910	20101210–20110731	2254	.64	4.22–1.04	pre!	GR_{un}	7.0	–	1b	0.47/4438	P4
			20101210–20110530	2104	.47	4.22–2.04		GR	6.5	–	1b	0.46/4135	P4
Sample B. Years 1970–2010. Almost complete sample of 69 near-parabolic comets of $q_{osc} \geq 3.1$ au and $1/a_{ori} < 100 \times 10^{-6}$ au^{-1}; exceptions: C/2008 S3, C/2009 F4, C/2010 S1 and C/2010 U3, all four are still observable at the end of 2013.													
C/1972 L1 Sandage	4.276	19721114	19720609–19741019	150	2.4	4.47–7.01	full	GR	7.5	–	1a	1.40/ 296	P2,1
C/1973 W1 Gibson	3.842	19730809	19731130–19741011	22	.86	3.97–5.29	post	GR	6.5	–	1b	0.72/ 43	P2
C/1974 V1 van den Bergh	6.019	19740807	19741112–19761031	46	2.0	6.06–8.19	post	GR	7.0	–	1b	1.16/ 92	P2
C/1976 D2 Shuster	6.881	19750115	19760225–19780407	57	2.1	7.37–10.1	post	GR	7.5	–	1a	1.00/ 111	P2
C/1976 U1 Lovas	5.857	19760706	19761122–19780210	30	1.2	5.94–7.14	post	GR	6.5	–	1b	1.69/ 60	P2
C/1978 A1 West	5.606	19770721	19760330–19790626	62	3.2	6.57–7.50	full	GR	7.5	–	1a	1.30/ 120	P2
C/1978 G2 McNaught	6.283	19780824	19780412–19800123	7	1.8	6.35–7.20	full	GR	6.5	–	1b	0.82/ 14	P2
C/1979 M3 Torres	4.687	19790715	19780823–19791023	34	1.2	5.34–4.75	full	GR	7.0	–	1b	1.34/ 64	P2
C/1980 E1 Bowell	3.364	19820312	19800211–19861230	203	6.9	7.47–13.9	full	NG	8.5	8.5	1a+	1.06/ 387	P2,1
C/1983 O1 Cernis	3.318	19830721	19830721–19910514	232	7.8	3.32–19.4	post	NG	8.5	7.5	1a	1.11/ 461	P2,1
C/1984 W2 Hartley	4.000	19850928	19841117–19880518	54	3.5	4.80–8.52	full	NG	7.5	7.5	1a	1.87/ 107	P2
C/1987 F1 Torres	3.625	19870410	19870328–19891227	56	2.7	3.63–8.75	post++	GR	8.0	–	1a	1.14/ 108	P2
C/1987 H1 Shoemaker	5.458	19861117	19870425–19920104	127	4.7	5.58–13.4	post	GR	8.5	–	1a+	0.91/ 242	P2,1
C/1987 W3 Jensen-Shoemaker	3.333	19880118	19870924–19900429	34	2.6	3.51–7.77	full	GR	7.5	–	1a	1.22/ 65	P2
C/1988 B1 Shoemaker	5.031	19870320	19880123–19920106	66	4.0	5.55–12.9	post	GR	7.5	–	1a	0.98/ 127	P2
C/1993 F1 Mueller	5.900	19920804	19930319–19950704	111	2.3	6.11–9.30	post	GR	7.5	–	1a	1.11/ 219	P2
C/1993 K1 Shoemaker-Levy	4.849	19940201	19930523–19960127	44	2.9	5.24–7.27	full	GR	7.5	–	1a	1.02/ 86	P2
C/1997 A1 NEAT	3.157	19970619	19970109–19971228	200	.97	3.52–3.65	full	GR	7.0	–	1b	0.55/ 400	new[3]
C/1997 BA_6 Spacewatch	3.436	19991127	19970111–20040915	529	7.7	9.15–13.4	full	NG	9.0	8.5	1a+	0.67/1054	P1,P2,1
C/1999 F1 Catalina	5.787	20020213	19990313–20050828	168	6.5	9.28–10.4	full	GR	9.0	–	1a+	0.43/ 330	new[4]
C/1999 F2 Delcanton	4.719	19980823	19980515–20000829	148	2.3	4.79–7.30	post++	GR	8.0	–	1a	0.73/ 293	P2,1
C/1999 H3 LINEAR	3.501	19990818	19990422–20020320	877	2.9	3.66–8.48	post+	NG	8.5	8.0	1a	0.51/1722	P2
C/1999 J2 LINEAR	7.110	20000406	19990512–20030529	1001	4.1	7.42–10.1	full	GR	9.0	–	1a+	0.53/1974	P2
C/1999 K5 LINEAR	3.255	20000704	19990515–20020318	250	2.8	5.00–6.36	full	GR	8.5	–	1a+	0.51/ 492	P2,1
C/1999 N4 LINEAR	5.505	20000523	19980827–20020506	345	3.7	7.14–7.49	full	GR	8.0	–	1a	0.53/ 661	new[5]
C/1999 S2 McNaught-Watson	6.467	19971122	19990919–20020216	98	2.4	7.84–11.7	post	GR	8.0	–	1a	0.48/ 184	P2
C/1999 U1 Ferris	4.138	19980903	19981222–20000128	208	1.1	4.24–5.89	post	GR	7.5	–	1a	0.51/ 410	P2
C/1999 U4 Catalina-Skiff	4.915	20011028	19990918–20040411	911	4.6	7.55–8.22	full	GR	9.0	–	1a+	0.78/1807	P2,1
C/2000 A1 Montani	9.743	20000713	20000104–20020320	132	2.2	9.80–10.3	full	GR	8.0	–	1a	0.45/ 264	P2
C/2000 CT_{54} LINEAR	3.156	20010619	19990321–20040117	210	4.8	7.72–8.52	full	NG	8.5	8.5	1a+	0.75/ 417	P2
C/2000 K1 LINEAR	6.276	19991214	19990518–20010815	333	2.2	6.44–7.51	post+	GR	8.0	–	1a	0.72/ 663	P2,1
C/2000 O1 Koehn	5.922	20000127	19981214–20010827	65	2.7	6.58–7.15	full	GR	8.0	–	1a	0.81/ 128	P2
C/2000 SV_{74} LINEAR	3.542	20020430	20000905–20050512	2189	4.7	6.26–9.51	full	NG	9.0	9.0	1a+	0.71/4349	P1,P2
C/2000 Y1 Tubbiolo	7.975	20010202	20001024–20021105	94	2.0	8.00–8.86	full	GR	8.0	–	1a	0.74/ 185	P2
C/2001 C1 LINEAR	5.105	20020328	20000429–20020703	223	2.2	7.24–5.16	pre++	GR	8.0	–	1a	0.67/ 436	P2
C/2001 G1 LONEOS	8.235	20011009	20001228–20030601	138	2.4	8.41–8.98	full	GR	8.0	–	1a	0.58/ 266	P2,1
C/2001 K5 LINEAR	5.184	20021011	20010430–20041125	3402	3.6	6.50–7.65	full	GR	8.5	–	1a+	0.66/6736	P2
C/2002 A3 LINEAR	5.151	20020424	20020113–20030624	291	1.4	5.21–6.05	full	GR	7.5	–	1a	0.49/ 573	P2,1
C/2002 J4 NEAT	3.634	20031003	20020504–20061001	232	4.4	5.74–9.38	full	GR	9.0	–	1a+	0.48/ 451	new[6]
C/2002 J5 LINEAR	5.727	20030919	20010806–20060305	618	4.6	7.87–8.44	full	GR	9.0	–	1a+	0.53/1227	P2,1

Table A.1. continued.

Comet name	q_{osc}	T	Observational arc dates	No of obs	Data arc span	Heliocentric distance span	Data type	Type of model	Q^* GR model	NG model	New orbital class	rms [arcsec] /no of res.	Ref & Notes
	[au]	[yyyymmdd]	[yyyymmdd–yyyymmdd]		[yr]	[au]							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
C/2002 L9 NEAT	7.033	20040406	20020606–20070111	323	4.6	8.23–9.48	full	GR	9.0	–	1a+	0.49/ 634	P2,1
C/2002 R3 LONEOS	3.869	20030613	20020904–20040524	1274	1.7	4.57–4.88	full	NG	8.0	7.5	1a	0.52/2530	P2,1
C/2003 G1 LINEAR	4.916	20030203	20030408–20041014	1484	1.5	4.94–6.77	post	GR	8.0	–	1a	0.54/2939	P2,1
C/2003 S3 LINEAR	8.129	20030410	20011223–20041023	124	2.8	8.61–8.80	full	GR	8.0	–	1a	0.49/ 242	new[7]
C/2003 WT_{42} LINEAR	5.191	20060410	20031030–20080525	2564	4.6	8.26–7.66	full	GR	9.0	–	1a+	0.53/5057	P2,1
C/2004 P1 NEAT	6.014	20030808	20030511–20050830	151	2.3	6.05–7.91	post++	GR	8.0	–	1a	0.63/ 298	P2
C/2004 T3 Siding Spring	8.865	20030415	20041012–20060131	109	1.3	9.40–10.6	post	GR	7.5	–	1a	0.44/ 209	P2,1
C/2004 X3 LINEAR	4.402	20050617	20041215–20060331	250	1.3	4.65–4.98	pre+	GR	7.5	–	1a	0.51/ 487	P2
C/2005 B1 Christensen	3.205	20060223	20040318–20071103	1517	3.6	6.94–5.49	full	NG	8.5	8.5	1a+	0.43/2985	P2
C/2005 EL_{173} LONEOS	3.886	20070305	20050303–20081117	317	3.7	7.12–6.45	full	NG	8.5	8.5	1a+	0.36/ 632	P2
C/2005 G1 LINEAR	4.961	20060227	20050322–20070311	292	2.0	5.61–5.73	full	GR	7.5	–	1a	0.49/ 573	P2
C/2005 K1 Skiff	3.693	20051121	20050516–20070806	642	2.2	4.06–6.42	full	NG	8.0	8.0	1a	0.52/1246	new[8]
C/2005 L3 McNaught	5.593	20080116	20040716–20130305	5337	8.7	10.3–13.4	full	GR	9.0	–	1a+	0.49/10503	new
C/2005 Q1 LINEAR	6.408	20050825	20050827–20071016	161	2.1	6.41–8.25	post	GR	8.0	–	1a	0.48/ 309	P2
C/2006 E1 McNaught	6.041	20070106	20060311–20090303	143	3.0	6.39–8.07	full	GR	8.0	–	1a	0.65/ 282	P2
C/2006 K1 McNaught	4.426	20070720	20060517–20090228	417	2.8	5.60–6.41	full	GR	8.5	–	1a+	0.47/ 829	P2
C/2006 S2 LINEAR	3.161	20070507	20060917–20070716	178	.83	3.86–3.23	full	NG	7.0	6.5	1b	0.44/ 346	P2
C/2006 S3 LONEOS	5.131	20120416	20060829–20130729	5214	6.9	14.4–6.22	full	GR	9.0	–	1a+	0.50/10589	new
C/2006 YC Catalina	4.948	20060911	20061216–20070415	147	0.3	5.00–5.22	post	GR	6.0	–	2a	0.42/ 286	P2
C/2007 D1 LINEAR	8.794	20070619	20070217–20130504	548	6.2	8.82–14.7	full	GR	9.0	–	1a+	0.45/1061	new
C/2007 JA_{21} LINEAR	5.368	20061114	20070511–20080827	174	1.3	5.53–7.14	post	GR	7.5	–	1a	0.47/ 342	P2
C/2007 VO_{53} Spacewatch	4.843	20100426	20071020–20120720	712	4.7	8.31–7.76	full	GR	9.0	–	1a+	0.43/1396	new
C/2007 Y1 LINEAR	3.341	20080319	20071216–20080503	209	.38	3.46–3.37	full	GR	6.0	–	2a	0.61/ 415	P2
C/2008 FK_{75} Lemmon-Siding S.	4.511	20100829	20080331–20131008	3704	5.5	8.24–9.34	full	GR	9.0	–	1a+	0.52/7349	new
C/2008 P1 Garradd	3.896	20090722	20080813–20110204	1373	2.5	4.88–6.08	full	GR	8.5	–	1a+	0.61/ 415	new
C/2009 P2 Boattini	6.544	20100210	20081001–20110729	503	2.8	7.33–7.53	full	GR	8.0	–	1a	0.51/ 982	new
C/2009 U5 Grauer	6.094	20100622	20091023–20110402	187	1.4	6.32–6.41	pre++	GR	7.5	–	1a	0.52/ 359	new
C/2010 D3 WISE	4.248	20100903	20100224–20130611	97	3.3	4.54–8.80	full	GR	8.0	–	1a	0.52/ 187	new
C/2010 R1 LINEAR	5.621	20120518	20100904–20130605	1574	2.7	7.15–6.26	full	GR	8.5	–	1a+	0.43/3106	new

Additional notes on some individual objects given in Table A.1

Comet C/1990 K1. MWC 08 gives an NG orbit based on significantly fewer observations (314) and the same time interval as in the table. In June 2013, 693 observations were available at the IAU Minor Planet Center Database (2013), but the osculating orbit was the same as in MWC 08. Since MWC 08 gives an NG orbit, orbital quality class is not given there. The pure GR osculating orbit (1a quality class[3]) given at the JPL Small-Body Database Browser (2013) is based on 553 observations. In Paper 1 the symmetric NG model based on full data interval was analysed, where some trends in O−C variations were reported. The present symmetric NG solution results in 1a quality class. The asymmetric model (function $g(r(t-\tau))$) listed in this catalogue gives $\tau = 5.3 \pm 1.7$ day and orbit of class 1b. However, still some trends in O−C time variations are easily seen and a more dedicated treatment is necessary for this comet, maybe similar to that in Paper 3 for C/2001 Q4 and C/2002 T7.

Comet C/1993 A1. MWC 08 gives NG orbit based on a poorer data set (539 observations) and shorter time interval (2 January 1993 – 10 June 1994). In June 2013, 745 observations were available at the IAU Minor Planet Center Database (2013), but the osculating orbit was the same as in MWC 08. Since MWC 08 gives an NG orbit, an orbital quality class is not given there. In Paper 1 the symmetric NG model based on the full data interval was used (orbit of class 1a) and some trends in O−C variations were reported. The asymmetric model (function $g(r(t-\tau))$) presented here gives $\tau = -34.2 \pm 3.2$ day and slightly decreasing rms (orbit of class 1a) compared with the GR model, but still some trends in O−C time variations are easily recognizable. Probably a more dedicated treatment is necessary for this comet, maybe similar to that in Paper 3 for C/2001 Q4 and C/2002 T7.

Comet C/2001 Q4. MWC 08 gives an NG orbit based on significantly fewer observations (1106) and shorter arc (4 August 2001–11 June 2004). In June 2013, 2681 observations were available at the IAU Minor Planet Center Database (2013), but the osculating orbit was the same as in MWC 08. Since MWC 08 gives an NG orbit, the orbital quality class is not given there. The NG osculating orbit (quality class 1a+) given at the JPL Small-Body Database Browser (2013) is based on 2567 observations. Here, two models are listed: (1) an NG solution based on a full data interval and (2) the most recommended model for past and future dynamical evolution. The first model gives NG orbit of class 1a+ with evident trends in O−C time variations. The asymmetric model gives $\tau = 0.73 \pm 0.45$ day, and no decrease in rms, therefore the symmetric model is included in this catalogue. The second model is based on data taken at large distances and gives orbit of class 1a+ and O−C time variations with no trends in right ascension and declination. In Paper 3, we recommend this model for dynamical studies and investigation of the origin of this comet. For more details see model DIST2 in Paper 3.

Comet C/2002 T7. MWC 08 gives an NG orbit based on 3825 observations and a significantly shorter arc (12 October 2002–11 June 2004). In June 2013, 4517 observations were available at the IAU Minor Planet Center Database (2013), which span the same time interval as in this table. However, the osculating orbit was the same as in MWC 08. Since MWC 08 gives an NG orbit, the orbital quality class is not given there. The NG osculating orbit (quality class 1a+) given at the JPL Small-Body Database Browser (2013) is based on 4399 observations and a slightly shorter data interval (12 October 2002–07 March 2006). Here, two models are listed: (1) an NG solution based on full data interval and (2) the most recommended models for past and future dynamical evolution, respectively. The first model gives an NG orbit of class 1a+ with evident trends in O−C time variations. The asymmetric model gives $\tau = -12.9 \pm 0.6$ day, $|A_1| \ll |A_2|$ and an infinitesimal decrease in rms, therefore the symmetric model is shown in this catalogue. The second (PRE) and third (POST) models are based on data taken before and after perihelion passage, respectively, and give orbits of class 1a and 1b as well as O−C time variations with no trends in right ascension and declination. In Paper 3, we recommend osculating orbits based on these two models to study the origin and future of this comet. For more details see model PRE in Paper 3.

Comet C/2003 K4. MWC 08 gives an GR orbit based on significantly fewer observations (2244) and shorter arc (28 May 2006 – 09 July 2004). In June 2013, 3712 observations were available at the IAU Minor Planet Center Database (2013) that span the same time interval as in this table, but the orbit was the same as in MWC 08. The NG osculating orbit (quality class 1a+) given at the JPL Small-Body Database Browser (2013) is based on 3606 observations. In Paper 1 the symmetric NG model based on a full data interval is given (orbit of class 1a+) and some trends in O−C variations are reported. The asymmetric model (function $g(r(t-\tau))$) gives a very long time shift $\tau = -89 \pm 3$ day and slightly decreasing rms (orbit of class 1a) compared with the symmetric NG solution, but still similar trends in O−C time variations are easily visible. Thus, two models are listed here: (1) the symmetric NG solution based on the full data interval (where observations are weighted slightly differently from the solutions investigated in Paper 1), and (2) the most recommended model for past and future dynamical evolution based on observations taken at large heliocentric distance from the Sun. In the second model no trends in O−C time variations are noted.

Comets C/2006 HW$_{51}$, C/2006 L2 and C/2008 T2. In Paper 4, we decided to analyse the GR solutions since the NG solutions give a negative normal component of NG acceleration (parameter $A_1 < 0$) for these comets which makes the NG solution rather uncertain. For more details see Paper 4.

Comet C/2006 VZ$_{13}$. MWC 08 gives a GR orbit (class 1B) based on 356 observations and the time interval of 13 November 2006−27 June 2007. In June 2013, 1173 observations were available at the IAU Minor Planet Center Database (2013) span the same time interval as the first model for this comet in our table. However, the orbit given at the IAU Minor Planet Center Database (2013) was the same as in MWC 08. The GR osculating orbit (quality class 1b) given at JPL Small-Body Database Browser (2013) is based on 1037 observations and the time interval 13 November 2006−05 August 2007. Since observations have stopped soon after perihelion passage, a dedicated solution is only possible for pre-perihelion data. Here, two models are listed: (1) the NG solution based on the full data interval, and (2) the most recommended model for past dynamical evolution. In Paper 4, we recommend this second solution (of quality class 2b) for backward dynamical studies and a NG solution based on all data for forward extrapolation of motion (class 1b) with the remark that the future motion of this comet is additionally uncertain because of the lack of post-perihelion data. For more details see Paper 4.

Comet C/2007 N3. Evident trends in the O−C time variations for the NG solution (important normal component of NG acceleration) based on an entire data set were noticed. Therefore we list in this catalogue two types of models: (1) an asymmetric

[3] At JPL Small-Body Database Browser (2013) no orbital quality assessment is published, thus we calculated here orbital class using our new scheme.

NG solution based on a full data interval, and (2) the most recommended two separate GR models based on pre-perihelion and post-perihelion data, for past and future dynamical evolution, respectively. Fore more details see Paper 4.

Comet C/2007 O1. According to the JPL Small-Body Database Browser (2013), this comet was also known as 2006 GA_{38}, therefore eight positional observations of this object were also used for orbit determination. For more details see Paper 4.

Comet C/2007 Q1. In MWC 08 and the JPL Small-Body Database Browser (2013) only a parabolic orbit for this comet is given (assumed $e = 1$ thus unknown 1/a, no quality class). For more details see Paper 4.

Comet C/2007 Q3. At the IAU Minor Planet Center Database (2013) over ten times more observations are available than were used in MWC 08 for the orbit determination. In Paper 4, we noted visible trends in the O−C solution for an NG solution based on all positional data. Therefore we list two types of models: (1) a symmetric NG solution based on a full data interval; and (2) the most recommended two separate GR models based on pre-perihelion and post-perihelion data, for past and future dynamical evolution, respectively. For more details see Paper 4.

Comet C/2007 W1. MWC 08 includes only a pure GR orbit of a class 1B for this comet (based on 344 observations taken until 16 Mar 2008). Here, 1703 observations given at the IAU Minor Planet Center Database (2013) were taken. Some part of them were used at the IAU Minor Planet Center Database (2013) to recalculate an orbit of this comet using the NG model. The GR osculating orbit (quality class 1b) given at the JPL Small-Body Database Browser (2013) is based on 599 observations and the data interval of 20 November 2007−30 August 2008. A full asymmetric NG model gives orbit of class 1a, but very strong trends in O−C diagram were noted and NG effects seem to be variable in the motion of C/2007 W1. Therefore in Paper 4, similarly to Nakano (2009a,b), we determined two dedicated NG orbits for backward and forward dynamical studies. The orbit based on pre-perihelion data is of class 1b while the post-perihelion solution gives an orbit of quality class 2b. In this catalogue the asymmetric NG solution based on the entire data set is slightly different from that used in Paper 4 (observations were selected using a more restrictive criterion). A detailed discussion of this unique comet is given in Paper 4.

Comet C/2008 A1. MWC 08 includes only a pure GR orbit of a class 1B for this comet (basing on 240 observations taken until 15 May 2008). Here, 937 observations given at the IAU Minor Planet Center Database (2013) were used. Some parts of them (until 1 May 2009) were used at the IAU Minor Planet Center Database (2013) to recalculate NG orbit of this comet. The GR osculating orbit (quality class 1a) given at JPL Small-Body Database Browser (2013) is based on 595 observations and the data interval of 10 January 2008−17 January 2010. See also Nakano (2009c). The full asymmetric NG model gives orbit of class 1a, but very strong trends in the O−C diagram were easily seen and NG effects seem to be variable in its motion. Because of the erratic behaviour of this comet we proposed in Paper 4 two different NG solutions (both class 1b) based on pre- and post-perihelion data (similarly to C/2007 W1). More details are given in Paper 4.

Comet C/2009 K5. In June 2013, 2544 observations were available at the IAU Minor Planet Center Database (2013), and the GR osculating orbit (class 1A) given there was based on 2307 observations, whereas the GR orbit (class 1a+) given at the JPL Small-Body Database Browser (2013) was based on 2487 observations. Some trends in O−C time variations in the pure GR model (class 1a+) based on an entire data set were noted. Therefore we recommend in Paper 4 two separate orbital solutions for the backward and forward dynamical orbital evolution of this comet, both are pure GR and give osculating orbits of class 1a. For more details see Paper 4.

Comet C/2010 X1. In June 2013, 2276 observations were available at the IAU Minor Planet Center Database (2013), the GR osculating orbit (class 1A) given there was based on 1896 observations and on the time interval of 10 December 2010−07 September 2011. The GR osculating orbit (quality class 1b) given at the JPL Small-Body Database Browser (2013) is based on 2209 observations taken within the data interval of 10 December 2010−1 August 2011. This comet was observed until 7 September, but started to disintegrating in August. Therefore the data for GR orbit determination were taken here until the end of July for the first model (as at JPL), and to the end of May for the second model. The first solution exhibits some trends in O−C time variation, the second model is much better and also gives orbit of class 1b. For more details see Paper 4.

Appendix B: Part II. Osculating orbital elements (heliocentric)

Table B.1. Heliocentric orbital elements of osculating orbits for 28 near-parabolic comets described as Sample A1 in Table A.1.

Comet	Epoch [yyyymmdd]	T [yyyymmdd.dddddd]	q [au]	e	ω [°]	Ω [°]	i [°]	$1/a_{osc}$ [10^{-6} au^{-1}]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Osculating barycentric orbits based on the entire data sets						
C/1885 X1	18860404	18860406.454383	0.64236680	1.00027315	126.588371	37.963059	82.628566	−425.22
		±.000284	±.00000206	±.00002319	±.000120	±.000094	±.000459	±36.10
C/1892 Q1	18930117	18921228.586707	0.97595829	1.00030422	252.651332	266.034217	24.800982	−311.72
		±.000228	±.00000584	±.00002555	±.000427	±.000181	±.000152	±26.18
C/1952 W1	19530123	19530124.861090	0.77770934	1.00005338	253.822072	343.580012	97.186308	−68.64
		±.000716	±.00001008	±.00014581	±.000446	±.000890	±.000812	±187.49
C/1956 R1	19561014	19570408.028353	0.31598046	1.00021561	308.783333	215.856589	119.939289	−682.34
		±.000158	±.00000245	±.00000369	±.000334	±.000090	±.000075	±11.68

Notes. The successive columns signify (1) – comet designation, (2) – epoch, i.e. osculation date, (3) – perihelion time [TT], (4) – perihelion distance, (5) – eccentricity, (6) – argument of perihelion (in degrees), equinox 2000.0, (7) – longitude of the ascending node (in degrees), equinox 2000.0, (8) – inclination (in degrees), equinox 2000.0, (9) – inverse semi-major axis in units of 10^{-6} au^{-1}.

Table B.1. continued.

Comet	Epoch [yyyymmdd]	T [yyyymmdd.dddddd]	q [au]	e	ω [°]	Ω [°]	i [°]	$1/a_{osc}$ [10^{-6} au^{-1}]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
C/1959 Y1	19591218	19600320.985705	0.50411205	1.00022392	306.651819	252.643185	159.600241	−444.19
		±.001030	±.00002431	±.00006252	±.002691	±.001127	±.000200	±124.03
C/1974 F1	19750816	19750822.181059	3.01143760	0.99958340	261.366389	12.368600	50.648531	138.34
		±.000455	±.00001130	±.00001388	±.000102	±.000046	±.000058	±4.61
C/1978 H1	19781128	19781111.408775	1.13650660	1.00079425	231.401425	349.344859	43.761723	−698.85
		±.000236	±.00000288	±.00000972	±.000104	±.000060	±.000084	±8.55
C/1986 P1	19870505	19870420.780693	1.19965105	1.00031319	238.307145	111.666056	147.119122	−261.07
		±.000054	±.00000087	±.00000315	±.000054	±.000041	±.000029	±2.63
C/1989 Q1	19891110	19891111.914664	0.64236124	1.00002499	150.564098	275.510766	90.146682	−38.91
		±.000138	±.00000070	±.00001665	±.000214	±.000275	±.000248	±25.92
C/1989 X1	19900419	19900409.967504	0.34977205	1.00021591	61.575931	75.925341	58.956430	−617.28
		±.000033	±.00000053	±.00000309	±.000097	±.000017	±.000065	±8.83
C/1990 K1	19901105	19901024.684234	0.93869530	1.00038579	242.665901	139.364541	131.582128	−410.98
		±.000102	±.00000199	±.00000931	±.000117	±.000033	±.000062	±9.91
C/1991 F2	19920119	19920120.026976	1.51771129	1.00040745	271.159246	11.834904	95.456595	−268.47
		±.000122	±.00000327	±.00000888	±.000035	±.000028	±.000089	±5.85
C/1992 J1	19930910	19930905.547819	3.00700702	0.99996278	83.400999	203.324053	124.318707	12.38
		±.000205	±.00000103	±.00000285	±.000042	±.000020	±.000019	±0.95
C/1993 A1	19921025	19940112.948616	1.93767483	1.00162360	130.666753	144.719771	124.878592	−837.91
		±.000218	±.00000382	±.00000420	±.000137	±.000026	±.000020	±2.17
C/1993 Q1	19940329	19940326.275403	0.96732722	1.00022433	261.024015	193.788651	105.025195	−231.90
		±.000376	±.00000951	±.00001560	±.000964	±.000287	±.000091	±16.12
C/1996 E1	19960207	19960727.353176	1.35878564	1.00078927	81.117630	149.841680	114.473289	−580.86
		±.000201	±.00000638	±.00000621	±.000330	±.000036	±.000027	±4.57
C/1997 J2	19980308	19980310.442478	3.05109435	1.00056658	122.674220	148.844627	91.273390	−185.70
		±.000111	±.00000118	±.00000179	±.000028	±.000006	±.000006	±0.59
C/1999 Y1	20010401	20010324.103143	3.09119483	1.00059789	184.283022	188.883981	134.786955	−193.42
		±.000123	±.00000131	±.00000265	±.000029	±.000012	±.000012	±0.86
C/2001 B1	20000913	20000919.286160	2.92799686	1.00055047	284.814463	49.831522	104.134304	−188.00
		±.000728	±.00001329	±.00000566	±.000348	±.000013	±.000082	±1.93
C/2001 K3	20010522	20010422.885552	3.06018209	0.99905199	3.454678	289.850306	52.026705	309.79
		±.002018	±.00001221	±.00002082	±.000569	±.000142	±.000265	±6.80
C/2001 Q4	20010730	20040516.066603	0.96136124	1.00056075	1.213428	210.200138	99.564090	−583.29
		±.000023	±.00000034	±.00000079	±.000050	±.000008	±.000011	±0.82
C/2002 E2	20020215	20020221.798122	1.46645893	1.00076303	9.038271	244.583534	92.545707	−520.32
		±.000269	±.00000133	±.00001166	±.000227	±.000030	±.000012	±7.95
C/2002 Q5	20021013	20021119.200638	1.24296640	1.00157379	133.306696	33.747176	149.164203	−1266.16
		±.000034	±.00000022	±.00000136	±.000043	±.000042	±.000011	±1.10
C/2002 T7	20020903	20040423.145295	0.61502190	1.00040155	157.722612	94.847709	160.571155	−652.90
		±.000020	±.00000030	±.00000021	±.000024	±.000011	±.000006	±0.34
C/2003 T3	20040714	20040429.001424	1.48107247	0.99973997	43.773334	347.057734	50.444430	175.57
		±.000045	±.00000031	±.00000104	±.000017	±.000017	±.000015	±0.70
C/2003 K4	20030501	20041013.697058	1.02406159	1.00043406	198.404190	18.651630	134.247399	−423.86
		±.000024	±.00000046	±.00000053	±.000036	±.000009	±.000003	±0.52
C/2004 B1	20060125	20060207.887081	1.60192826	1.00127077	327.899930	272.801920	114.096796	−793.27
		±.000034	±.00000040	±.00000112	±.000009	±.000008	±.000010	±0.70
C/2005 E2	20060531	20060223.472800	1.51957158	1.00013668	39.966307	347.846942	16.988159	−89.94
		±.000058	±.00000047	±.00000117	±.000033	±.000032	±.000009	±0.77
Osculating orbits based on DIST or pre-perihelion data sets								
C/2001 Q4	20010730	20040516.066034	0.96137487	1.00057161	1.212369	210.199931	99.563785	−594.58
		±.000057	±.00000086	±.00000094	±.000069	±.000015	±.000015	±0.97
C/2002 T7	20020903	20040423.145323	0.61503075	1.00040642	157.722134	94.847872	160.571223	−660.81
		±.000029	±.00000039	±.00000030	±.000033	±.000013	±.000007	±0.49
C/2003 K4	20030501	20041013.706563	1.02405532	1.00041390	198.405628	18.651602	134.247433	−404.18
		±.000658	±.00000118	±.00000162	±.000089	±.000033	±.000008	±1.58
Osculating orbits based on post-perihelion data sets								
C/2002 T7	20040,425	20040423.059326	0.61458627	1.00041363	157.729574	94.855782	160.582686	−673.03
		±.000109	±.00000045	±.00001161	±.000254	±.000121	±.000053	±18.88

Table B.2. Heliocentric orbital elements of osculating orbits for 22 near-parabolic comets described as sample A2 in Table A.1.

Comet (1)	Epoch [yyyymmdd] (2)	T [yyyymmdd.dddddd] (3)	q [au] (4)	e (5)	ω [°] (6)	Ω [°] (7)	i [°] (8)	$1/a_{\rm osc}$ [10^{-6} au^{-1}] (9)
Osculating orbits from the entire data sets								
C/2006 HW$_{51}$	20060922	20060929.310348	2.26564503	1.00224866	359.959683	228.127986	45.809385	−992.50
		±.000161	±.00000071	±.00000774	±.000044	±.000038	±.000024	±3.42
C/2006 K3	20070301	20070313.363489	2.50143944	1.00085639	328.075919	49.402938	92.619710	−342.36
		±.000363	±.00000237	±.00000599	±.000136	±.000029	±.000020	±2.40
C/2006 L2	20061101	20061120.199547	1.99394772	1.00093781	48.034772	239.246068	101.022297	−470.33
		±.000122	±.00000069	±.00000284	±.000043	±.000012	±.000023	±1.42
C/2006 OF$_2$	20080911	20080915.684505	2.43143593	1.00083257	95.612164	318.508002	30.170411	−342.42
		±.000024	±.00000043	±.00000075	±.000008	±.000004	±.000003	±0.31
C/2006 P1	20070120	20070112.798838	0.17073161	1.00001723	155.975453	267.415065	77.837245	−100.92
		±.000024	±.00000031	±.00000119	±.000077	±.000025	±.000025	±6.99
C/2006 Q1	20080623	20080703.855033	2.76363984	0.99977124	344.379539	199.546472	59.046972	82.77
		±.000040	±.00000054	±.00000097	±.000007	±.000005	±.000003	±0.35
C/2006 VZ$_{13}$	20070808	20070810.892820	1.01524745	0.99994377	174.117028	66.029510	134.792098	55.39
		±.000175	±.00000091	±.00001270	±.000257	±.000123	±.000065	±12.51
C/2007 N3	20090109	20090110.640067	1.21225654	0.99997682	136.862765	338.535488	178.373633	19.12
		±.000006	±.00000007	±.00000045	±.000042	±.000041	±.000004	±0.37
C/2007 O1	20070520	20070603.298842	2.87671670	1.00498807	159.400786	116.235193	24.379508	−1733.95
		±.001027	±.00000778	±.00001343	±.000267	±.000027	±.000055	±4.66
C/2007 Q1	20061211	20061211.841512	3.00637895	1.00306045	282.566815	5.833679	82.222742	−1017.99
		±.753344	±.02053679	±.00223242	±.525540	±.066746	±.243520	±732.72
C/2007 Q3	20091016	20091007.265422	2.25169273	1.00025939	2.090436	149.412849	65.650440	−115.20
		±.000050	±.00000065	±.00000171	±.000012	±.000008	±.000005	±0.76
C/2007 W1	20080623	20080624.885133	0.84967565	1.00010098	306.550830	334.523804	9.889166	−118.84
		±.000007	±.00000012	±.00000132	±.000026	±.000030	±.000010	±1.56
C/2007 W3	20080514	20080602.797246	1.77661017	1.00011024	112.626588	73.068697	78.673567	−62.05
		±.000262	±.00000537	±.00001251	±.000223	±.000079	±.000045	±7.04
C/2008 A1	20080911	20080929.127602	1.07306392	1.00018943	348.477291	277.883733	82.549129	−176.53
		±.000067	±.00000067	±.00000225	±.000083	±.000026	±.000012	±2.10
C/2008 C1	20080404	20080416.850463	1.26235106	1.00001641	180.927722	307.782181	61.784755	−13.00
		±.000316	±.00000365	±.00001468	±.000308	±.000150	±.000068	±11.63
C/2008 J6	20080404	20080410.943490	2.00350304	1.00225379	10.703471	298.178229	44.987216	−1124.92
		±.000197	±.00000282	±.00000814	±.000100	±.000078	±.000041	±4.06
C/2008 T2	20090213	20090613.239633	1.20221618	1.00011611	215.870786	309.678336	56.303838	−96.58
		±.000046	±.00000061	±.00000129	±.000038	±.000021	±.000015	±1.07
C/2009 K5	20100614	20100430.024135	1.42239751	1.00083926	66.173720	257.856116	103.879415	−590.03
		±.000009	±.00000009	±.00000028	±.000006	±.000003	±.000005	±0.20
C/2009 O4	20090831	20100101.277442	2.56378209	1.00132657	223.732314	172.936519	95.823000	−517.42
		±.001055	±.00000799	±.00001263	±.000350	±.000026	±.000156	±4.92
C/2009 R1	20100411	20100702.675680	0.40501846	1.00035977	130.700102	322.622314	77.034327	−888.27
		±.000232	±.00000260	±.00000121	±.000199	±.000032	±.000192	±2.98
C/2010 H1	20100524	20100618.881912	2.74566505	0.99969990	233.813390	347.384822	36.532756	109.30
		±.011591	±.00007134	±.00002811	±.004331	±.000494	±.000714	±10.24
C/2010 X1	20110827	20110910.722328	0.48245682	1.00003111	343.805622	323.226953	1.839257	−64.49
		±.000158	±.00000164	±.00000106	±.000487	±.000494	±.000026	±2.20
Osculating orbits from pre-perihelion data sets for investigating the past dynamical evolution								
C/2006 VZ$_{13}$	20070808	20070810.891488	1.01525293	1.00015482	174.115421	66.028203	134.792653	−152.49
		±.000334	±.00000258	±.00005613	±.000746	±.000817	±.000454	±55.29
C/2007 N3	20090109	20090110.640177	1.21226490	0.99998333	136.866852	338.539889	178.373604	13.75
		±.000037	±.00000096	±.00000073	±.000153	±.000144	±.000005	±0.60
C/2007 Q3	20091016	20091007.267137	2.25167770	1.00022406	2.091211	149.413010	65.650162	−99.51
		±.000153	±.00000128	±.00000119	±.000046	±.000013	±.000004	±0.53
C/2007 W1	20080623	20080624.887029	0.84965694	1.00011020	306.549632	334.528730	9.889591	−129.70
		±.000159	±.00000169	±.00000309	±.000384	±.000683	±.000041	±3.64
C/2008 A1	20080911	20080929.125802	1.07308711	1.00026451	348.474897	277.882018	82.550006	−246.49
		±.000332	±.00000375	±.00001289	±.000437	±.000212	±.000100	±12.01
C/2009 K5	20100614	20100430.024020	1.42239454	1.00084485	66.173708	257.856117	103.879483	−593.96
		±.000038	±.00000032	±.00000080	±.000028	±.000006	±.000008	±0.56
Osculating orbits from post-perihelion data sets for investigating the future dynamical evolution								
C/2007 N3	20090109	20090110.642206	1.21225069	0.99998422	136.863235	338.535924	178.373830	13.01
		±.000866	±.00000451	±.00000255	±.000550	±.000552	±.000008	±2.11
C/2007 Q3	20091016	20091007.262200	2.25171331	1.00025450	2.090673	149.412480	65.650754	−113.02
		±.001604	±.00001520	±.00000829	±.000332	±.000108	±.000025	±3.68
C/2007 W1	20080623	20080624.887438	0.84968619	1.00010121	306.554562	334.523444	9.888552	−119.11
		±.000639	±.00000646	±.00002732	±.000676	±.000279	±.000515	±32.15
C/2008 A1	20080911	20080929.124280	1.07294448	0.99955656	348.472703	277.886946	82.556261	413.29
		±.000432	±.00000714	±.00003447	±.000583	±.000197	±.000473	±32.12
C/2009 K5	20100614	20100430.024291	1.42240448	1.00084178	66.174037	257.856122	103.879388	−591.80
		±.000023	±.00000056	±.00000058	±.000024	±.000004	±.000007	±0.41

Notes. The successive columns signify (1) – comet designation, (2) – epoch, i.e. osculation date, (3) – perihelion time [TT], (4) – perihelion distance, (5) – eccentricity, (6) – argument of perihelion (in degrees), equinox 2000.0, (7) – longitude of the ascending node (in degrees), equinox 2000.0, (8) – inclination (in degrees), equinox 2000.0, (9) – inverse semi-major axis in units of 10^{-6} au^{-1}.

Table B.3. Heliocentric orbital elements of osculating orbits for 69 near-parabolic comets described as sample B in Table A.1.

Comet (1)	Epoch [yyyymmdd] (2)	T [yyyymmdd.dddddd] (3)	q [au] (4)	e (5)	ω [°] (6)	Ω [°] (7)	i [°] (8)	$1/a_{\rm osc}$ [10^{-6} au^{-1}] (9)
C/1972 L1	19721119	19721114.809745	4.27576201	1.00636268	56.657922	225.485976	79.367842	−1488.08
		±.003887	±.00001790	±.00002624	±.000583	±.000118	±.000073	±6.13
C/1973 W1	19730826	19730809.894467	3.84227589	1.00063440	221.260826	244.600667	108.066889	−165.11
		±.006669	±.00008706	±.00004761	±.002045	±.000280	±.000095	±12.39
C/1974 V1	19740821	19740807.763518	6.01885058	1.00391195	151.758534	226.104055	60.853679	−649.95
		±.018901	±.00009141	±.00007181	±.001823	±.000069	±.000200	±11.90
C/1976 D2	19750128	19750115.546664	6.88076913	1.00210991	193.427853	22.786964	112.025871	−306.64
		±.013003	±.00009833	±.00005133	±.001429	±.000179	±.000136	±7.46
C/1976 U1	19760701	19760706.362248	5.85727320	1.00388129	118.787189	286.037188	86.631909	−662.64
		±.036083	±.00014296	±.00012609	±.003919	±.000293	±.000358	±21.51
C/1978 A1	19770805	19770721.555156	5.60632765	1.00294290	343.283932	211.623628	116.930129	−524.92
		±.006685	±.00003869	±.00006749	±.000542	±.000070	±.000162	±12.03
C/1978 G2	19780909	19780824.540076	6.28283701	1.00213685	229.509423	72.215982	153.182919	−340.11
		±.027455	±.00026742	±.00023866	±.002489	±.000451	±.000230	±37.94
C/1979 M3	19790726	19790715.404937	4.68691254	1.00106133	10.101298	293.136635	92.178173	−226.44
		±.011173	±.00004288	±.00006640	±.001499	±.000082	±.000337	±14.16
C/1980 E1	19820312	19820312.294755	3.36388555	1.05725600	135.085598	114.555728	1.661772	−17020.79
		±.000438	±.00000955	±.00001080	±.000892	±.000890	±.000025	±3.13
C/1983 O1	19830705	19830721.247954	3.31791426	1.00190643	186.220505	209.578776	134.698671	−574.59
		±.012645	±.00001672	±.00006801	±.002908	±.000048	±.000037	±20.49
C/1984 W1	19850912	19850928.377250	4.00019640	0.99956150	255.267920	250.208162	89.327140	109.62
		±.006835	±.00003608	±.00003854	±.001006	±.000101	±.000096	±9.63
C/1987 F1	19870326	19870410.278029	3.62460449	1.00101531	329.089760	194.487714	124.079942	−280.12
		±.002348	±.00001506	±.00001802	±.000451	±.000055	±.000075	±4.97
C/1987 H1	19861126	19861117.104282	5.45751848	1.00284157	16.995673	268.325863	132.474265	−520.67
		±.004053	±.00003120	±.00001548	±.000555	±.000079	±.000057	±2.83
C/1987 W3	19871231	19880118.808909	3.33281436	1.00477970	194.736359	198.345564	76.715895	−1434.13
		±.002680	±.00001639	±.00002465	±.000546	±.000086	±.000095	±7.38
C/1988 B1	19870326	19870320.107555	5.03070649	1.00248504	124.217043	325.159660	80.585940	−493.97
		±.009206	±.00007222	±.00003544	±.001331	±.000038	±.000139	±7.03
C/1993 F1	19920806	19920804.502761	5.90039749	1.00574936	61.992684	77.515654	53.940015	−974.40
		±.010589	±.00006949	±.00003689	±.001170	±.000132	±.000051	±6.22
C/1993 K1	19940217	19940201.947760	4.84927746	1.00023279	232.445275	30.328581	67.766928	−48.01
		±.003910	±.00002489	±.00003717	±.000466	±.000102	±.000070	±7.66
C/1997 A1	19970601	19970619.592489	3.15719754	1.00205075	40.013168	135.766750	145.071757	−649.55
		±.000501	±.00000229	±.00000507	±.000111	±.000017	±.000026	±1.60
C/1997 BA$_6$	19991208	19991127.566151	3.43630558	0.99882316	285.935698	317.663829	72.714861	342.47
		±.000334	±.00000451	±.00000508	±.000033	±.000010	±.000022	±1.48
C/1999 F1	20020215	20020213.749973	5.78693483	0.99884880	255.166695	20.012519	92.029856	198.93
		±.000540	±.00000227	±.00000334	±.000040	±.000011	±.000014	±0.58
C/1999 F2	19980815	19980823.988272	4.71880860	0.99863745	352.393463	210.295764	56.421004	288.75
		±.002572	±.00001514	±.00001566	±.000353	±.000051	±.000049	±3.32
C/1999 H3	19990810	19990818.241961	3.50080910	1.00269373	101.912685	332.723748	115.840364	−769.46
		±.000870	±.00000249	±.00000619	±.000199	±.000035	±.000012	±1.77
C/1999 J2	20000406	20000406.004255	7.10975456	1.00103030	127.140062	50.042583	86.412706	−144.91
		±.000912	±.00000468	±.00000456	±.000063	±.000012	±.000009	±0.64
C/1999 K5	20000625	20000704.392540	3.25538203	1.00167918	241.487043	106.381812	89.473112	−515.82
		±.000322	±.00000088	±.00000306	±.000043	±.000011	±.000024	±0.94
C/1999 N4	20000516	20000523.734622	5.50473873	1.00419246	90.429037	345.901293	156.922915	−761.61
		±.000816	±.00000628	±.00000778	±.000097	±.000045	±.000009	±1.41
C/1999 S2	19971108	19971122.532219	6.46669745	1.00725540	223.477051	74.427229	65.813130	−1121.96
		±.006487	±.00004864	±.00002471	±.000614	±.000142	±.000028	±3.82
C/1999 U1	19980815	19980903.028007	4.13756580	1.00365011	291.063317	58.257256	105.734810	−882.19
		±.003494	±.00002406	±.00001242	±.000628	±.000024	±.000121	±2.99
C/1999 U4	20011018	20011028.456827	4.91532891	1.00766217	77.511961	32.288874	51.926317	−1558.83
		±.000242	±.00000132	±.00000263	±.000024	±.000011	±.000009	±0.53
C/2000 A1	20000625	20000713.137414	9.74312736	1.00388320	14.265914	111.835674	24.542798	−398.56
		±.011178	±.00002922	±.00001921	±.000509	±.000042	±.000049	±1.97

Notes. All osculating orbits in this table are based on the entire data sets. The successive columns signify (1) – comet designation, (2) – epoch, i.e. osculation date, (3) – perihelion time [TT], (4) – perihelion distance, (5) – eccentricity, (6) – argument of perihelion (in degrees), equinox 2000.0, (7) – longitude of the ascending node (in degrees), equinox 2000.0, (8) – inclination (in degrees), equinox 2000.0, (9) – inverse semi-major axis in units of 10^{-6} au^{-1}.

Table B.3. continued.

Comet	Epoch [yyyymmdd]	T [yyyymmdd.dddddd]	q [au]	e	ω [°]	Ω [°]	i [°]	$1/a_{osc}$ [10^{-6} au^{-1}]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
C/2000 CT$_{54}$	20010620	20010619.500943	3.15599443	0.99861902	272.649348	18.964790	49.206633	437.57
		±.000247	±.00000824	±.00000833	±.000048	±.000019	±.000042	±2.64
C/2000 K1	19991208	19991214.799671	6.27611470	1.00240548	15.814601	260.194253	116.782036	−383.27
		±.002273	±.00001447	±.00001457	±.000212	±.000028	±.000037	±2.32
C/2000 O1	20000117	20000127.393232	5.92165320	1.00069750	55.112765	88.862048	148.097534	−117.79
		±.003402	±.00002637	±.00002806	±.000318	±.000114	±.000041	±4.74
C/2000 SV$_{74}$	20020506	20020430.474295	3.54159163	1.00479822	76.226350	24.185277	75.237116	−1354.82
		±.000097	±.00000176	±.00000219	±.000016	±.000005	±.000009	±0.62
C/2000 Y1	20010401	20010202.142668	7.97474088	1.00268899	181.731551	239.395267	137.976898	−337.19
		±.012487	±.00004697	±.00003350	±.000767	±.000036	±.000104	±4.19
C/2001 C1	20020327	20020328.292956	5.10462770	0.99991178	219.936408	33.711279	68.951920	17.28
		±.002413	±.00001150	±.00001068	±.000274	±.000013	±.000050	±2.09
C/2001 G1	20011018	20011009.141613	8.23542303	1.00244802	343.278402	203.889833	45.368344	−297.25
		±.008279	±.00003133	±.00002288	±.000468	±.000024	±.000044	±2.77
C/2001 K5	20021013	20021011.769734	5.18425260	0.99962590	47.056315	237.461926	72.593297	72.16
		±.000225	±.00000140	±.00000210	±.000023	±.000006	±.000005	±0.40
C/2002 A3	20020506	20020424.397426	5.15143918	1.00791266	329.479955	136.550845	48.039047	−1536.01
		±.003120	±.00000756	±.00000927	±.000348	±.000010	±.000017	±1.79
C/2002 J4	20031008	20031003.151072	3.63378023	1.00001831	230.705722	70.881227	46.521834	−5.04
		±.000235	±.00000105	±.00000356	±.000035	±.000014	±.000015	±0.98
C/2002 J5	20031008	20030919.309165	5.72679475	1.00116654	74.832954	314.110065	117.228214	−203.70
		±.000422	±.00000292	±.00000388	±.000039	±.000013	±.000007	±0.68
C/2002 L9	20040425	20040406.052495	7.03303845	0.99850170	231.431509	110.457237	68.445540	213.04
		±.000771	±.00000591	±.00000615	±.000050	±.000011	±.000011	±0.87
C/2002 R3	20030610	20030613.470930	3.86946979	1.00267793	45.067172	54.296421	161.095581	−692.07
		±.001417	±.00000421	±.00000700	±.000275	±.000057	±.000012	±1.81
C/2003 G1	20030210	20030203.652081	4.91629490	1.00125341	11.421359	246.091987	66.855788	−254.95
		±.000638	±.00000352	±.00000313	±.000093	±.000010	±.000017	±0.63
C/2003 S3	20030322	20030410.253543	8.12943090	1.00142723	154.553947	226.389152	151.496771	−175.56
		±.004094	±.00003043	±.00002358	±.000233	±.000035	±.000029	±2.90
C/2003 WT$_{42}$	20060415	20060410.766380	5.19092643	1.00256857	92.467227	48.453841	31.410656	−494.82
		±.000181	±.00000115	±.00000168	±.000021	±.000008	±.000003	±0.32
C/2004 P1	20030720	20030808.923813	6.01409659	0.99873180	16.596434	284.193932	28.823571	210.87
		±.006332	±.00003034	±.00001857	±.000685	±.000238	±.000094	±3.09
C/2004 T3	20030501	20030415.234572	8.86450665	0.99749028	259.677146	50.392989	71.959969	283.12
		±.024763	±.00008577	±.00003702	±.001656	±.000134	±.000050	±4.17
C/2004 X3	20050530	20050617.237423	4.40225166	1.00625095	202.133519	343.045098	81.063070	−1419.94
		±.001410	±.00000568	±.00000937	±.000207	±.000014	±.000082	±2.13
C/2005 B1	20060306	20060223.575863	3.20492463	1.00026916	103.183642	195.556016	92.551290	−83.98
		±.000110	±.00000121	±.00000160	±.000024	±.000004	±.000011	±0.50
C/2005 EL$_{173}$	20070301	20070305.871906	3.88631166	1.00333283	261.493679	344.796425	130.679610	−857.58
		±.000180	±.00000283	±.00000329	±.000034	±.000009	±.000008	±0.84
C/2005 G1	20060306	20060227.383771	4.96067147	0.99979762	113.825055	299.586688	108.414423	40.80
		±.000994	±.00000433	±.00000508	±.000120	±.000029	±.000010	±1.02
C/2005 K1	20051106	20051121.217840	3.69287282	1.00327669	134.943605	106.304986	77.747678	−887.30
		±.000908	±.00000357	±.00000422	±.000193	±.000023	±.000012	±1.14
C/2005 L3	20080115	20080116.005851	5.59327050	0.99991033	47.096947	288.739107	139.448742	16.03
		±.000088	±.00000047	±.00000071	±.000009	±.000004	±.000002	±0.13
C/2005 Q1	20050818	20050825.529483	6.40841016	1.00447731	44.691595	87.727459	105.188309	−698.66
		±.003554	±.00001266	±.00001322	±.000311	±.000045	±.000033	±2.06
C/2006 E1	20070120	20070106.507436	6.04057919	1.00121653	232.779293	95.034571	83.193442	−201.39
		±.002770	±.00001081	±.00001344	±.000228	±.000037	±.000049	±2.22
C/2006 K1	20070808	20070720.550991	4.42551584	1.00147580	296.442241	72.114889	53.876951	−333.47
		±.000347	±.00000227	±.00000414	±.000042	±.000010	±.000009	±0.93
C/2006 S2	20070520	20070507.356456	3.16144197	1.00206698	166.342741	113.885818	98.962277	−653.81
		±.006086	±.00000729	±.00001973	±.001530	±.000032	±.000053	±6.24
C/2006 S3	20120423	20120416.331021	5.13114696	1.00351254	140.130169	38.370805	166.032646	−684.55
		±.000113	±.00000061	±.00000083	±.000016	±.000011	±.000003	±0.16
C/2006 YC	20060922	20060911.776952	4.94821307	1.00023183	335.518236	154.288752	69.558721	−46.85
		±.031475	±.00013935	±.00006089	±.004348	±.000125	±.001653	±12.30
C/2007 D1	20070629	20070619.460865	8.79372556	1.00191986	340.159247	171.098537	41.450252	−218.32
		±.002729	±.00001369	±.00000846	±.000141	±.000008	±.000013	±0.96

Table B.3. continued.

Comet	Epoch [yyyymmdd]	T [yyyymmdd.dddddd]	q [au]	e	ω [°]	Ω [°]	i [°]	$1/a_{osc}$ [10^{-6} au^{-1}]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
C/2007 JA_{21}	20061101	20061114.373398	5.36815179	1.00230714	93.697721	65.522369	89.840317	−429.78
		±.003150	±.00001740	±.00001092	±.000388	±.000030	±.000022	±2.03
C/2007 Y1	20080404	20080319.334554	3.34090683	1.00074172	357.128047	133.091508	110.179814	−222.01
		±.002282	±.00001666	±.00004139	±.000534	±.000091	±.000359	±12.39
C/2007 VO_{53}	20100504	20100426.499302	4.84262750	0.99972382	75.029920	59.736874	86.990322	57.03
		±.000198	±.00000113	±.00000169	±.000023	±.000007	±.000006	±0.35
C/2008 FK_{75}	20101011	20100929.255517	4.51085684	1.00253851	80.420270	218.268510	61.175997	−562.76
		±.000092	±.00000065	±.00000112	±.000012	±.000004	±.000003	±0.25
C/2008 P1	20090728	20090722.935905	3.89610720	1.00176244	11.862585	357.676590	64.308943	−452.36
		±.000243	±.00000108	±.00000214	±.000040	±.000005	±.000009	±0.55
C/2009 P2	20100213	20100210.863085	6.54387710	1.00183747	76.088005	60.392108	163.455157	−280.79
		±.001278	±.00000891	±.00000903	±.000124	±.000066	±.000011	±1.38
C/2009 U5	20100613	20100622.379910	6.09432663	0.99967469	23.804900	121.172427	25.470398	53.38
		±.009093	±.00001434	±.00001116	±.000786	±.000045	±.000086	±1.83
C/2010 D3	20100901	20100903.915130	4.24752343	0.99956603	304.641320	255.238093	76.391671	102.17
		±.001010	±.00000425	±.00000490	±.000134	±.000010	±.000022	±1.15
C/2010 R1	20120602	20120518.897264	5.62142117	1.00366427	114.496326	343.649456	156.933395	−651.84
		±.000329	±.00000251	±.00000290	±.000037	±.000017	±.000004	±0.52

Table B.4. NG parameters derived in orbital solutions based on entire data intervals (first-line solution for a given comet marked STD in Col. (6)) and those based on a subsample of data marked PRE or POST (see also Table A.1).

Comet	NG parameters defined by Eq. (2) in units of 10^{-8} au day^{-2}			τ	model
	A_1	A_2	A_3	[days]	type
(1)	(2)	(3)	(4)	(5)	(6)
		Sample A1			
C/1885 X1	2.337 ± 0.295	−0.288 ± 0.161	–	–	STD
C/1892 Q1	2.779 ± 0.405	0.199 ± 0.385	–	–	STD
C/1952 W1	3.84 ± 1.90	−0.489 ± 0.181	–	–	STD
C/1956 R1	1.948 ± 0.139	0.1123 ± 0.0223	0.3728 ± 0.0873	–	STD
C/1959 Y1	9.482 ± 0.730	1.276 ± 0.309	0.725 ± 0.154	−9.3	STD
C/1974 F1	50.9 ± 38.0	−1.0 ± 30.8	−14.29 ± 6.73	–	STD
C/1978 H1	1.292 ± 0.198	0.415 ± 0.125	–	–	STD
C/1986 P1-A	1.750 ± 0.0600	0.0034 ± 0.0271	–	–	STD
C/1989 Q1	3.396 ± 0.317	0.506 ± 0.149	–	–	STD
C/1989 X1	0.2675 ± 0.0729	0.0327 ± 0.0221	–	–	STD
C/1990 K1	3.694 ± 0.163	−0.0736 ± 0.0769	0.3001 ± 0.0122	5.3 ± 1.7	STD
C/1991 F2	0.656 ± 0.230	−0.340 ± 0.134	0.0724 ± 0.0379	–	STD
C/1993 A1	14.458 ± 0.215	0.135 ± 0.279	−0.0890 ± 0.0627	−34.2 ± 3.2	STD
C/1993 Q1	3.829 ± 0.336	0.864 ± 0.128	0.455 ± 0.186	–	STD
C/1996 E1	6.688 ± 0.311	0.6882 ± 0.0935	–	–	STD
C/1997 J2	292.74 ± 6.92	−50.39 ± 6.35	–	–	STD
C/1999 Y1	296.45 ± 7.64	48.9 ± 10.4	5.31 ± 3.40	–	STD
C/2001 Q4	1.6506 ± 0.0140	0.06240 ± 0.00610	0.0141 ± 0.0511	–	STD
	1.2132 ± 0.0267	0.03323 ± 0.00721	0.17907 ± 0.00920	–	DIST
C/2002 E2	2.780 ± 0.232	0.879 ± 0.194	–	–	STD
C/2002 T7	0.3822 ± 0.0158	0.30233 ± 0.00416	−0.15256 ± 0.00433	–	STD
	5.582 ± 0.583	1.632 ± 0.498	0.679 ± 0.154	–	PRE
	1.414 ± 0.106	0.4371 ± 0.0781	−0.4016 ± 0.0292	–	POST
C/2003 K4	0.8522 ± 0.0171	−0.43620 ± 0.00607	−0.06644 ± 0.00432	–	STD
	0.3299 ± 0.0407	0.1058 ± 0.0256	−0.1252 ± 0.0148	–	DIST
C/2004 B1	0.9131 ± 0.0334	−0.3503 ± 0.0177	−0.23725 ± 0.00683	–	STD
		Sample A2			
C/2006 K3	15.69 ± 1.67	2.25 ± 2.45	−0.209 ± 0.576	–	STD
C/2006 OF$_2$	2.384 ± 0.168	−1.370 ± 0.131	−0.0059 ± 0.0347	–	STD
C/2006 P1	0.1329 ± 0.0335	0.03138 ± 0.00397	–	–	STD
C/2006 Q1	33.504 ± 0.700	1.916 ± 0.550	10.604 ± 0.189	–	STD
C/2006 VZ$_{13}$	4.576 ± 0.115	−3.041 ± 0.135	1.2204 ± 0.0741	–	STD
	1.874 ± 0.804	−0.866 ± 0.483	0.528 ± 0.404	–	PRE
C/2007 N3	0.08678 ± 0.00814	−0.02141 ± 0.00696	−0.13334 ± 0.00190	11.3 ± 1.9	STD
C/2007 Q3	0.156 ± 0.180	2.675 ± 0.103	1.657 ± 0.037	–	STD
C/2007 W1	3.97480 ± 0.00841	−0.4266 ± 0.0138	−0.06387 ± 0.00276	24.7 ± 4.3	STD
	1.002 ± 0.139	−0.7253 ± 0.0321	−0.4916 ± 0.0703	–	PRE
	5.864 ± 0.272	−0.783 ± 0.172	0.136 ± 0.250	–	POST
C/2007 W3	4.968 ± 0.572	2.248 ± 0.581	−1.084 ± 0.316	–	STD
C/2008 A1	5.5964 ± 0.0570	0.7136 ± 0.0384	0.16800 ± 0.00815	5.76 ± 0.61	STD
	4.608 ± 0.136	1.894 ± 0.233	1.844 ± 0.203	–	PRE
	10.094 ± 0.282	6.142 ± 0.291	−4.431 ± 0.306	–	POST
C/2009 R1	5.798 ± 0.490	−1.418 ± 0.359	0.776 ± 0.207	–	STD
		Sample B			
C/1980 E1	1095 ± 181	535.89 ± 93.1	–	–	STD
C/1983 O1	2683 ± 942	158.10 ± 677	–	–	STD
C/1984 W2	36 844 ± 23 157	–	–	–	STD
C/1997 BA$_6$	3341 ± 118	24.3 ± 54.1	−29.8 ± 11.7	–	STD
C/1999 H3	4112 ± 193	3007 ± 228	−509.0 ± 72.0	–	STD
C/2000 CT$_{54}$	778.0 ± 53.6	51.5 ± 25.9	–	–	STD
C/2000 SV$_{74}$	6121.6 ± 80.2	717.9 ± 60.7	−513.6 ± 21.7	–	STD
C/2002 R3	17850 ± 2640	5810 ± 3510	–	–	STD
C/2005 B1	74.7 ± 12.6	−77.7 ± 9.17	−63.94 ± 4.66	–	STD
C/2005 EL$_{173}$	6602 ± 773	−7175 ± 496	–	–	STD
C/2005 K1	2515 ± 741	184 ± 762	–	–	STD
C/2006 S2	772 ± 299	−167 ± 199	–	–	STD

Appendix C: Part III. Original barycentric orbital elements

Table C.1. Orbital elements of original barycentric orbits, i.e. before entering the planetary zone for 28 near-parabolic comets described as sample A1 in Table A.1.

Comet	Epoch [yyyymmdd]	T [yyyymmdd.dddddd]	q [au]	e	ω [°]	Ω [°]	i [°]	$1/a_{\rm ori}$ [10^{-6} au^{-1}]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Original barycentric orbits based on the entire data sets						
C/1885 X1	15880117	18860405.846922	0.63999379	0.99996093	126.676913	37.853210	82.756505	61.04
		±0.000595	±0.00000574	±0.00001099	±0.000644	±0.000093	±0.000459	±17.17
C/1892 Q1	15940415	18921228.151231	0.97466329	0.99994340	252.541362	266.215494	24.770458	58.07
		±0.001357	±0.00001784	±0.00004960	±0.001495	±0.000171	±0.000148	±50.89
C/1952 W1	16550415	19530124.009962	0.77523403	1.00000006	253.927686	343.653652	97.162914	−0.07
		±0.001204	±0.00003670	±0.00006651	±0.003436	±0.000900	±0.000824	±85.79
C/1956 R1	16600319	19570408.524057	0.31732219	0.99999671	308.755188	215.775015	119.986140	10.37
		±0.003917	±0.00000252	±0.00000363	±0.000333	±0.000087	±0.000075	±11.42
C/1959 Y1	16621214	19600321.812727	0.50420900	0.99999895	306.647899	252.547496	159.618575	2.09
		±0.001586	±0.00002659	±0.00006372	±0.002740	±0.001019	±0.000250	±126.38
C/1974 F1	16730619	19750821.673310	3.01230367	0.99987782	261.346466	12.362194	50.610951	40.56
		±0.001378	±0.00001431	±0.00001505	±0.000421	±0.000047	±0.000064	±5.00
C/1978 H1	16790807	19781110.596515	1.12973415	0.99990900	231.441739	349.549453	43.760229	80.55
		±0.000480	±0.00000615	±0.00001212	±0.000543	±0.000059	±0.000086	±10.72
C/1986 P1	16880511	19870420.100152	1.19367382	0.99994987	238.187130	111.413536	147.182259	42.00
		±0.000097	±0.00000163	±0.00000235	±0.000103	±0.000041	±0.000028	±1.97
C/1989 Q1	16911112	19891110.997724	0.64067579	0.99997251	150.615177	275.483828	89.973369	42.90
		±0.000392	±0.00000348	±0.00001425	±0.000450	±0.000276	±0.000251	±22.24
C/1989 X1	16921106	19900409.258092	0.34831385	0.99998577	61.656955	75.909182	58.983562	40.84
		±0.000128	±0.00000156	±0.00000345	±0.000303	±0.000017	±0.000065	±9.89
C/1990 K1	16910715	19901024.553182	0.93928599	0.99989327	242.645221	139.298604	131.574011	113.63
		±0.000176	±0.00000288	±0.00000570	±0.000316	±0.000026	±0.000071	±6.07
C/1991 F2	16921106	19920118.919635	1.51348314	0.99997844	271.252214	11.832361	95.452472	14.24
		±0.000253	±0.00000532	±0.00000609	±0.000271	±0.000025	±0.000085	±4.03
C/1992 J1	16910824	19930904.172357	3.00047429	0.99991839	83.453441	203.272834	124.287539	27.20
		±0.000204	±0.00000106	±0.00000281	±0.000042	±0.000020	±0.000019	±0.94
C/1993 A1	16930704	19940113.880951	1.94259216	0.99987986	130.672574	144.723714	124.970430	61.84
		±0.000224	±0.00000386	±0.00000428	±0.000137	±0.000027	±0.000020	±2.20
C/1993 Q1	16960110	19940326.010524	0.96693428	0.99998817	261.116266	193.890790	104.974100	12.24
		±0.000202	±0.00000866	±0.00000595	±0.000560	±0.000119	±0.000235	±6.15
C/1996 E1	16970613	19960727.311034	1.36236744	0.99995892	81.089949	149.760222	114.474859	30.15
		±0.000153	±0.00000644	±0.00000621	±0.000331	±0.000036	±0.000027	±4.56
C/1997 J2	16951201	19980311.421738	3.05072071	0.99986383	122.719964	148.795626	91.242267	44.64
		±0.000238	±0.00000159	±0.00000270	±0.000065	±0.000006	±0.000006	±0.88
C/1999 Y1	16981115	20010324.030859	3.08406653	0.99985392	184.263825	188.750285	134.797953	47.37
		±0.000210	±0.00000163	±0.00000290	±0.000051	±0.000014	±0.000010	±0.94
C/2001 B1	16980429	20000919.495624	2.92741701	0.99977040	284.863084	49.766597	104.117932	78.43
		±0.000779	±0.00001356	±0.00000577	±0.000357	±0.000013	±0.000083	±1.97
C/2001 K3	16990214	20010423.383672	3.06886844	0.99990440	3.350967	289.836411	51.968638	31.15
		±0.002066	±0.00001189	±0.00002074	±0.000568	±0.000139	±0.000262	±6.76
C/2001 Q4	17050831	20040516.039333	0.96047294	0.99994184	1.322963	210.315484	99.749234	60.56
		±0.000036	±0.00000035	±0.00000077	±0.000050	±0.000008	±0.000011	±0.81
C/2002 E2	17020228	20020221.797582	1.47022961	0.99986829	9.055695	244.655045	92.551268	89.59
		±0.000761	±0.00000456	±0.00001822	±0.000627	±0.000030	±0.000011	±12.39
C/2002 Q5	17031021	20021120.348184	1.25026531	0.99994161	133.240735	33.718928	149.330682	46.70
		±0.000045	±0.00000022	±0.00000138	±0.000044	±0.000043	±0.000012	±1.10
C/2002 T7	17060717	20040423.021385	0.61543684	0.99998421	157.728765	94.834931	160.521009	25.65
		±0.000021	±0.00000031	±0.00000020	±0.000024	±0.000011	±0.000006	±0.34
C/2003 K4	17060319	20041013.574142	1.02053946	0.99996796	198.550756	18.663783	134.279113	31.39
		±0.000025	±0.00000046	±0.00000052	±0.000036	±0.000009	±0.000003	±0.51
C/2003 T3	17041124	20040429.100888	1.48623673	0.99994731	43.684625	347.082802	50.412830	35.45
		±0.000046	±0.00000032	±0.00000105	±0.000017	±0.000017	±0.000015	±0.70
C/2004 B1	17060717	20060208.897763	1.60641136	0.99994236	327.914718	272.794963	114.147484	35.88
		±0.000074	±0.00000067	±0.00000110	±0.000042	±0.000008	±0.000011	±0.68
C/2005 E2	17061120	20060223.457894	1.52138713	0.99996876	39.858883	347.977213	16.989868	20.54
		±0.000064	±0.00000050	±0.00000116	±0.000033	±0.000032	±0.000009	±0.76
		Original barycentric orbits based on DIST or pre-perihelion data sets						
C/2001 Q4	17051010	20040516.038651	0.96048645	0.99995266	1.321905	210.315277	99.748930	49.29
		±0.000062	±0.00000086	±0.00000093	±0.000068	±0.000015	±0.000015	±0.96
C/2002 T7	17060826	20040423.021348	0.61544567	0.99998907	157.728285	94.835092	160.521073	17.75
		±0.000020	±0.00000038	±0.00000025	±0.000029	±0.000012	±0.000006	±0.41
C/2003 K4	17051229	20041013.583724	1.02053316	0.99994788	198.552191	18.663745	134.279144	51.07
		±0.000667	±0.00000119	±0.00000163	±0.000090	±0.000034	±0.000008	±1.60

Notes. The successive columns signify (1) – comet designation, (2) – epoch, i.e. osculation date, (3) – perihelion time [TT], (4) – perihelion distance, (5) – eccentricity, (6) – argument of perihelion (in degrees), equinox 2000.0, (7) – longitude of the ascending node (in degrees), equinox 2000.0, (8) – inclination (in degrees), equinox 2000.0, (9) – inverse original semi-major axis in units of 10^{-6} au^{-1}.

Table C.2. Orbital elements of original barycentric orbits, i.e. before entering the planetary zone for 22 near-parabolic comets described as sample A2 in Table A.1.

Comet	Epoch [yyyymmdd]	T [yyyymmdd.dddddd]	q [au]	e	ω [°]	Ω [°]	i [°]	$1/a_{\rm ori}$ [10^{-6} au^{-1}]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Original barycentric orbits based on the entire data sets								
C/2006 HW_{51}	17051119	20060929.574079	2.25933969	0.99989312	0.105489	228.163370	45.856715	47.31
		±0.000189	±0.00000070	±0.00000762	±0.000043	±0.000038	±0.000023	±3.37
C/2006 K3	16110913	20070313.052038	2.50325995	0.99984724	328.074663	49.427949	92.612447	61.02
		±0.000278	±0.00000304	±0.00001158	±0.000153	±0.000043	±0.000018	±4.63
C/2006 L2	17061114	20061119.409644	1.98559713	0.99997441	48.229422	239.260861	101.044452	12.89
		±0.000117	±0.00000069	±0.00000283	±0.000042	±0.000012	±0.000023	±1.43
C/2006 OF_2	17070930	20080914.944190	2.42852246	0.99994849	95.624276	318.584757	30.144295	21.21
		±0.000090	±0.00000063	±0.00000119	±0.000030	±0.000006	±0.000003	±0.49
C/2006 P1	17090919	20070112.337643	0.17003705	0.99999028	155.996155	267.457817	77.653337	57.17
		±0.000032	±0.00000048	±0.00000069	±0.000090	±0.000026	±0.000025	±4.03
C/2006 Q1	17060826	20080703.956583	2.76497731	0.99985877	344.363245	199.515362	59.015604	51.08
		±0.000105	±0.00000073	±0.00000133	±0.000029	±0.000007	±0.000005	±0.48
C/2006 VZ_{13}	17090810	20070811.243902	1.01301129	1.00001871	174.163643	65.978921	134.779717	−18.47
		±0.000194	±0.00000078	±0.00000392	±0.000117	±0.000024	±0.000008	±3.87
C/2007 N3	17100226	20090109.707426	1.20594372	0.99996094	136.944658	338.502932	178.368268	32.39
		±0.000015	±0.00000010	±0.00000022	±0.000137	±0.000133	±0.000005	±0.17
C/2007 O1	18650901	20070604.639851	2.86341562	0.99993314	159.569295	116.490036	24.427713	23.35
		±0.001058	±0.00000781	±0.00001347	±0.000269	±0.000028	±0.000055	±4.70
C/2007 Q1	17040727	20061211.984218	3.01650403	0.99983424	282.426335	5.878485	82.334247	54.95
		±0.694185	±0.02069906	±0.00241193	±0.527724	±0.068642	±0.235727	±799.16
C/2007 Q3	17081213	20091007.093891	2.25546432	0.99991174	2.067338	149.432081	65.620443	39.13
		±0.000113	±0.00000098	±0.00000110	±0.000044	±0.000009	±0.000004	±0.49
C/2007 W1	17101203	20080625.604804	0.85571663	1.00002492	306.193581	334.735622	9.764012	−29.12
		±0.000034	±0.00000021	±0.00000110	±0.000038	±0.000037	±0.000012	±1.30
C/2007 W3	17080706	20080602.926806	1.77616467	0.99994427	112.658345	73.055983	78.636651	31.38
		±0.000337	±0.00000621	±0.00000684	±0.000223	±0.000058	±0.000073	±3.85
C/2008 A1	17090122	20080929.788657	1.07272957	0.99986798	348.519718	277.853954	82.555262	123.07
		±0.000061	±0.00000096	±0.00000161	±0.000056	±0.000021	±0.000013	±1.50
C/2008 C1	17090412	20080416.808453	1.26642335	0.99995115	180.877694	307.783053	61.737844	38.57
		±0.000373	±0.00000361	±0.00001490	±0.000311	±0.000153	±0.000069	±11.77
C/2008 J6	17080128	20080410.927250	1.99507614	0.99994943	10.882624	298.266609	45.029402	25.35
		±0.000174	±0.00000278	±0.00000797	±0.000100	±0.000077	±0.000040	±4.00
C/2008 T2	17101019	20090613.071253	1.20556870	0.99998527	215.823242	309.716794	56.285125	12.22
		±0.000044	±0.00000062	±0.00000128	±0.000038	±0.000021	±0.000015	±1.06
C/2009 K5	17101204	20100428.968140	1.41933411	0.99992985	66.205134	257.740137	103.924710	49.42
		±0.000013	±0.00000008	±0.00000029	±0.000006	±0.000003	±0.000005	±0.20
C/2009 O4	17080630	20091231.718738	2.55680478	0.99985692	223.896771	172.974938	95.832953	55.96
		±0.001011	±0.00000794	±0.00001255	±0.000350	±0.000027	±0.000156	±4.91
C/2009 R1	17130408	20100701.169302	0.39442252	0.99999520	131.134477	322.671047	77.008392	12.16
		±0.000278	±0.00000159	±0.00000130	±0.000137	±0.000036	±0.000137	±3.29
C/2010 H1	17090323	20100619.145776	2.74743452	1.00000959	233.787592	347.407257	36.505749	−3.49
		±0.012050	±0.00007428	±0.00002954	±0.004486	±0.000507	±0.000741	±10.75
C/2010 X1	17140317	20110911.579239	0.48158241	0.99998839	343.653876	323.416873	1.876287	24.10
		±0.000172	±0.00000166	±0.00000106	±0.000479	±0.000486	±0.000026	±2.20
Original barycentric orbits based on pre-perihelion data sets								
C/2006 VZ_{13}	17090412	20070811.247241	1.01301057	0.99998585	174.164610	65.978852	134.779701	13.96
		±0.000688	±0.00000132	±0.00000486	±0.000185	±0.000093	±0.000041	±4.79
C/2007 N3	17100226	20090109.707500	1.20595272	0.99996465	136.943949	338.502617	178.368253	29.31
		±0.000039	±0.00000094	±0.00000072	±0.000153	±0.000145	±0.000005	±0.59
C/2007 Q3	17081213	20091007.094186	2.25545290	0.99990547	2.067678	149.432150	65.620427	41.91
		±0.000155	±0.00000129	±0.00000120	±0.000046	±0.000013	±0.000004	±0.53
C/2007 W1	17110112	20080625.604947	0.85572750	1.00003655	306.192555	334.735976	9.764146	−42.71
		±0.000155	±0.00000091	±0.00000200	±0.000063	±0.000048	±0.000016	±2.34
C/2008 A1	17090122	20080929.789350	1.07273156	0.99987037	348.519683	277.854140	82.555436	120.84
		±0.000230	±0.00000106	±0.00000218	±0.000069	±0.000028	±0.000022	±2.03
C/2009 K5	17101204	20100428.968071	1.41933112	0.99993542	66.205123	257.740138	103.924779	45.50
		±0.000031	±0.00000030	±0.00000078	±0.000027	±0.000006	±0.000007	±0.55

Notes. The successive columns signify (1) – comet designation, (2) – epoch, i.e. osculation date, (3) – perihelion time [TT], (4) – perihelion distance, (5) – eccentricity, (6) – argument of perihelion (in degrees), equinox 2000.0, (7) – longitude of the ascending node (in degrees), equinox 2000.0, (8) – inclination (in degrees), equinox 2000.0, (9) – inverse original semi-major axis in units of 10^{-6} au^{-1}.

Table C.3. Orbital elements of original barycentric orbits, i.e. before entering the planetary zone for 69 near-parabolic comets described as sample B in Table A.1.

Comet	Epoch [yyyymmdd]	T [yyyymmdd.dddddd]	q [au]	e	ω [°]	Ω [°]	i [°]	$1/a_{\rm ori}$ [10^{-6} au^{-1}]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
C/1972 L1	16680605	19721115.398710	4.26458890	0.99978206	56.882790	225.480163	79.487939	51.11
		±0.003935	±0.00001844	±0.00002648	±0.000579	±0.000117	±0.000073	±6.21
C/1973 W1	16690819	19730810.055023	3.84026288	0.99972033	221.390019	244.629964	108.049930	72.83
		±0.006665	±0.00008612	±0.00004727	±0.002037	±0.000278	±0.000094	±12.31
C/1974 V1	16670721	19740808.164070	6.01579264	0.99989464	151.829672	226.121112	60.878468	17.51
		±0.019246	±0.00009240	±0.00007279	±0.001856	±0.000068	±0.000198	±12.10
C/1976 D2	16660107	19750115.346261	6.88171236	0.99960808	193.436940	22.762585	111.987797	56.95
		±0.013214	±0.00010043	±0.00005032	±0.001461	±0.000180	±0.000138	±7.31
C/1976 U1	16690531	19760706.996700	5.85519975	0.99973363	118.864652	286.024042	86.663827	45.49
		±0.035841	±0.00014134	±0.00012792	±0.003893	±0.000293	±0.000353	±21.85
C/1978 A1	16701212	19770722.686250	5.60844086	0.99978957	343.384843	211.662760	116.926807	37.52
		±0.006476	±0.00003815	±0.00006666	±0.000535	±0.000069	±0.000160	±11.89
C/1978 G2	16710809	19780826.698113	6.28038625	1.00014083	229.651662	72.211404	153.162815	−22.42
		±0.026870	±0.00026610	±0.00023760	±0.002461	±0.000457	±0.000234	±37.83
C/1979 M3	16740614	19790715.600960	4.69146981	0.99980792	10.141099	293.185694	92.150900	40.94
		±0.011067	±0.00004325	±0.00006821	±0.001486	±0.000083	±0.000337	±14.54
C/1980 E1	16790916	19820405.040362	3.16929496	0.99983093	134.605868	120.631047	1.770359	53.35
		±0.002147	±0.00001463	±0.00001228	±0.000889	±0.000751	±0.000039	±3.87
C/1983 O1	16800801	19830721.857189	3.32563612	0.99979769	186.280264	209.611749	134.684921	60.83
		±0.018492	±0.00001829	±0.00012012	±0.004512	±0.000056	±0.000037	±36.12
C/1984 W2	16820212	19850929.038315	4.00453691	0.99991890	255.286662	250.227075	89.263792	20.25
		±0.014076	±0.00004945	±0.00003430	±0.002360	±0.000102	±0.000096	±8.56
C/1987 F1	16831114	19870409.792606	3.62427914	0.99978940	329.061349	194.483295	124.014019	58.11
		±0.002309	±0.00001504	±0.00001801	±0.000450	±0.000055	±0.000076	±4.97
C/1987 H1	16800622	19861116.537694	5.45109244	0.99975221	16.935975	268.239805	132.519096	45.46
		±0.004017	±0.00003114	±0.00001545	±0.000553	±0.000079	±0.000056	±2.83
C/1987 W3	16850706	19880119.288960	3.32264693	0.99991866	195.061575	198.376791	76.786374	24.48
		±0.002646	±0.00001598	±0.00002412	±0.000542	±0.000087	±0.000095	±7.26
C/1988 B1	16811015	19870319.600552	5.03079825	0.99989942	124.243345	325.210131	80.573568	19.99
		±0.009221	±0.00007241	±0.00003516	±0.001322	±0.000038	±0.000139	±6.99
C/1993 F1	16850308	19920806.153786	5.89949798	0.99963062	62.056088	77.524079	53.980307	62.61
		±0.010511	±0.00006956	±0.00003712	±0.001154	±0.000133	±0.000050	±6.29
C/1993 K1	16881127	19940131.665129	4.84471237	0.99985892	232.436917	30.322178	67.735390	29.12
		±0.003962	±0.00002505	±0.00003712	±0.000468	±0.000103	±0.000070	±7.66
C/1997 A1	16950405	19970620.169495	3.16326982	0.99993098	40.022006	135.720211	145.046895	21.82
		±.000519	±0.00000236	±0.00000519	±0.000115	±0.000018	±0.000027	±1.64
C/1997 BA_6	16970213	19991128.142457	3.44037125	0.99989050	285.894624	317.682671	72.629264	31.83
		±0.000636	±0.00000574	±0.00000397	±0.000149	±0.000011	±0.000022	±1.15
C/1999 F1	16950224	20020213.923640	5.78838144	0.99978554	255.192725	20.024735	91.973855	37.05
		±0.000557	±0.00000234	±0.00000343	±0.000041	±0.000011	±0.000014	±0.59
C/1999 F2	16930525	19980824.023182	4.72811386	0.99977816	352.298488	210.295378	56.362989	46.92
		±0.002527	±0.00001507	±0.00001569	±0.000353	±0.000052	±0.000050	±3.32
C/1999 H3	16950803	19990817.116521	3.50442230	0.99956311	101.831498	332.721955	115.908160	124.67
		±0.001361	±0.00000377	±0.00001359	±0.000316	±0.000075	±0.000011	±3.88
C/1999 J2	16910317	20000405.275717	7.11363383	0.99984298	127.111565	50.100055	86.368939	22.07
		±0.000916	±0.00000474	±0.00000460	±0.000063	±0.000011	±0.000009	±0.65
C/1999 K5	16980208	20000703.418653	3.25370073	0.99993034	241.511845	106.284045	89.488511	21.41
		±0.000333	±0.00000086	±0.00000308	±0.000044	±0.000011	±0.000024	±0.95
C/1999 N4	16930704	20000523.006014	5.51393119	0.99961003	90.320748	345.906966	156.940933	70.72
		±0.000829	±0.00000622	±0.00000788	±0.000100	±0.000046	±0.000009	±1.43
C/1999 S2	16890725	19971122.443555	6.46202592	0.99963528	223.496648	74.396105	65.872236	56.44
		±0.006530	±0.00004912	±0.00002453	±0.000617	±0.000142	±0.000027	±3.80
C/1999 U1	16940808	19980903.427579	4.13652185	0.99984302	291.151039	58.213827	105.825193	37.95
		±0.003547	±0.00002415	±0.00001239	±0.000628	±0.000024	±0.000122	±3.00
C/1999 U4	16960618	20011029.942046	4.88670740	0.99984462	77.829741	32.387465	52.060460	31.80
		±0.000253	±0.00000124	±0.00000257	±0.000025	±0.000011	±0.000010	±0.53
C/2000 A1	16861029	20000715.206584	9.74094723	0.99960423	14.342181	111.888001	24.552710	40.63
		±0.011038	±0.00002930	±0.00001927	±0.000503	±0.000041	±0.000049	±1.98

Notes. All original orbits in this table are based on the osculating orbits determined from the entire data sets. The successive columns signify (1) – comet designation, (2) – epoch, i.e. osculation date, (3) – perihelion time [TT], (4) – perihelion distance, (5) – eccentricity, (6) – argument of perihelion (in degrees), equinox 2000.0, (7) – longitude of the ascending node (in degrees), equinox 2000.0, (8) – inclination (in degrees), equinox 2000.0, (9) – inverse original semi-major axis in units of 10^{-6} au^{-1}.

Table C.3. continued.

Comet (1)	Epoch [yyyymmdd] (2)	T [yyyymmdd.dddddd] (3)	q [au] (4)	e (5)	ω [°] (6)	Ω [°] (7)	i [°] (8)	$1/a_{\rm ori}$ [10^{-6} au^{-1}] (9)
C/2000 CT$_{54}$	16980827	20010620.058041	3.16327619	0.99976954	272.560232	18.986874	49.142424	72.86
		±0.001270	±0.00001040	±0.00000967	±0.000318	±0.000019	±0.000041	±3.06
C/2000 K1	16920311	19991213.536382	6.27823901	0.99974889	15.737694	260.123450	116.745943	40.00
		±0.002299	±0.00001463	±0.00001453	±0.000216	±0.000028	±0.000038	±2.31
C/2000 O1	16920927	20000128.212579	5.91487290	0.99969254	55.184190	88.877691	148.072564	51.98
		±0.003342	±0.00002655	±0.00002809	±0.000313	±0.000115	±0.000040	±4.75
C/2000 SV$_{74}$	16980827	20020430.081681	3.52665831	0.99967447	76.492877	24.152963	75.360907	92.31
		±0.000341	±0.00000232	±0.00000301	±0.000070	±0.000010	±0.000012	±0.85
C/2000 Y1	16900210	20010203.415766	7.96805733	0.99951843	181.777248	239.382014	138.029678	60.44
		±0.012454	±0.00004701	±0.00003372	±0.000767	±0.000036	±0.000103	±4.23
C/2001 C1	16960906	20020328.801115	5.11002022	0.99991858	219.952566	33.760054	68.910831	15.93
		±0.002426	±0.00001152	±0.00001070	±0.000276	±0.000013	±0.000050	±2.09
C/2001 G1	16900829	20011010.850895	8.23895535	0.99966545	343.332494	203.944602	45.357940	40.61
		±0.008190	±0.00003115	±0.00002270	±0.000464	±0.000024	±0.000043	±2.76
C/2001 K5	16970325	20021011.974538	5.18958159	0.99994997	47.066240	237.490666	72.541315	9.64
		±0.000225	±0.00000140	±0.00000210	±0.000023	±0.000006	±0.000005	±0.41
C/2002 A3	16960906	20020425.196888	5.14305257	0.99989342	329.552549	136.668883	48.065967	20.72
		±0.003135	±0.00000772	±0.00000939	±0.000350	±0.000010	±0.000017	±1.83
C/2002 J4	17000817	20031003.506725	3.63841226	0.99987674	230.676162	70.946574	46.492041	33.88
		±0.000244	±0.00000105	±0.00000360	±0.000035	±0.000015	±0.000016	±0.99
C/2002 J5	16960906	20030919.798348	5.72509311	0.99966097	74.902635	314.051668	117.213649	59.22
		±0.000416	±0.00000298	±0.00000388	±0.000039	±0.000013	±0.000007	±0.68
C/2002 L9	16950224	20040405.561118	7.03551955	0.99974285	231.448525	110.454062	68.399334	36.55
		±0.000769	±0.00000600	±0.00000627	±0.000050	±0.000011	±0.000011	±0.89
C/2002 R3	16991001	20030613.160670	3.87017657	0.99981363	44.821560	54.088264	161.179102	48.16
		±0.001468	±0.00000698	±0.00001189	±0.000251	±0.000025	±0.000037	±3.07
C/2003 G1	16971120	20030204.386002	4.92065682	0.99993277	11.459666	246.149796	66.833236	13.66
		±0.000633	±0.00000353	±0.00000313	±0.000092	±0.000010	±0.000017	±0.64
C/2003 S3	16920530	20030409.093744	8.12669499	0.99971781	154.380377	226.284679	151.518010	34.72
		±0.004294	±0.00003132	±0.00002426	±0.000246	±0.000037	±0.000030	±2.99
C/2003 WT	17000419	20060411.899174	5.18222200	0.99976466	92.604965	48.434857	31.434392	45.41
		±0.000185	±0.00000123	±0.00000168	±0.000021	±0.000008	±0.000003	±0.32
C/2004 P1	16960509	20030809.041740	6.02262457	0.99981290	16.535459	284.228301	28.798128	31.07
		±0.006290	±0.00003005	±0.00001835	±0.000689	±0.000240	±0.000095	±3.05
C/2004 T3	16901227	20030414.895405	8.86554953	0.99959502	259.686943	50.389055	71.923588	45.68
		±0.024434	±0.00008464	±0.00003724	±0.001643	±0.000134	±0.000050	±4.20
C/2004 X3	17010414	20050618.219538	4.38911289	0.99994104	202.411327	343.029540	81.169463	13.43
		±0.001403	±0.00000571	±0.00000930	±0.000206	±0.000014	±0.000081	±2.12
C/2005 B1	17040109	20060222.262070	3.20593580	0.99998720	103.106005	195.570413	92.497575	3.99
		±0.000227	±0.00000162	±0.00000195	±0.000054	±0.000012	±0.000012	±0.61
C/2005 EL$_{173}$	17030623	20070305.845896	3.88759263	0.99982582	261.492080	344.763229	130.759788	44.81
		±0.000536	±0.00000374	±0.00000387	±0.000096	±0.000009	±0.000008	±0.99
C/2005 G1	17001215	20060226.533616	4.95322048	0.99991785	113.858813	299.571155	108.385968	16.58
		±0.000969	±0.00000434	±0.00000505	±0.000118	±0.000029	±0.000009	±1.02
C/2005 K1	17021205	20051121.776254	3.69197608	0.99996944	135.026925	106.341220	77.810523	8.28
		±0.001340	±0.00000503	±0.00000974	±0.000316	±0.000024	±0.000012	±2.64
C/2005 L3	17010305	20080115.292269	5.58682654	0.99965548	47.073480	288.707828	139.391017	61.67
		±0.000088	±0.00000053	±0.00000070	±0.000009	±0.000004	±0.000002	±0.13
C/2005 Q1	16971120	20050826.530305	6.39876801	0.99985473	44.829145	87.678330	105.254459	22.70
		±0.003639	±0.00001266	±0.00001307	±0.000317	±0.000045	±0.000033	±2.04
C/2006 E1	16991001	20070106.056920	6.03607650	0.99980395	232.838489	95.075848	83.188779	32.48
		±0.002773	±0.00001088	±0.00001350	±0.000230	±0.000036	±0.000048	±2.24
C/2006 K1	17030404	20070720.112692	4.42388653	0.99992817	296.473838	72.153187	53.870510	16.24
		±0.000348	±0.00000230	±0.00000410	±0.000042	±0.000010	±0.000009	±0.93
C/2006 S2	17040727	20070508.028917	3.15839357	0.99977096	166.480582	113.906396	99.006662	72.52
		±0.003363	±0.00001988	±0.00002572	±0.000797	±0.000032	±0.000054	±8.14
C/2006 S3	17061114	20120415.863838	5.13372946	0.99997163	140.028609	38.303879	166.015371	5.53
		±0.000113	±0.00000053	±0.00000083	±0.000016	±0.000011	±0.000003	±0.16
C/2006 YC	17010305	20060911.372759	4.94671296	0.99977378	335.521538	154.250213	69.543022	45.73
		±0.031507	±0.00013762	±0.00005955	±0.004357	±0.000123	±0.001630	±12.04

Table C.3. continued.

Comet (1)	Epoch [yyyymmdd] (2)	T [yyyymmdd.dddddd] (3)	q [au] (4)	e (5)	ω [°] (6)	Ω [°] (7)	i [°] (8)	$1/a_{\rm ori}$ [10^{-6} au^{-1}] (9)
C/2007 D1	16950515	20070619.627616	8.79200698	0.99961354	340.120329	171.125352	41.426988	43.96
		±0.002693	±0.00001358	±0.00000832	±0.000140	±0.000008	±0.000014	±0.95
C/2007 JA_{21}	17000419	20061115.586363	5.36590022	0.99965064	93.783567	65.483271	89.879449	65.11
		±0.003223	±0.00001785	±0.00001073	±0.000393	±0.000030	±0.000022	±2.00
C/2007 Y1	17050722	20080318.752689	3.34342252	0.99988596	357.085840	133.054139	110.125744	34.11
		±0.002305	±0.00001664	±0.00004164	±0.000533	±0.000092	±0.000364	±12.46
C/2007 VO_{53}	17040508	20100426.227350	4.84064308	0.99955267	75.075823	59.767764	86.965774	92.41
		±0.000199	±0.00000115	±0.00000172	±0.000023	±0.000007	±0.000005	±0.36
C/2008 FK_{75}	17051229	20100929.366575	4.50558286	0.99983540	80.520456	218.228874	61.190150	36.53
		±0.000091	±0.00000070	±0.00000113	±0.000012	±0.000004	±0.000003	±0.25
C/2008 P1	17040727	20090722.891761	3.89043249	0.99941649	11.963829	357.736840	64.317061	149.98
		±0.000239	±0.00000111	±0.00000214	±0.000039	±0.000005	±0.000009	±0.55
C/2009 P2	17020119	20100211.788872	6.54119059	0.99986297	76.054900	60.336867	163.445524	20.95
		±0.001311	±0.00000894	±0.00000906	±0.000126	±0.000066	±0.000011	±1.38
C/2009 U5	17021205	20100622.599308	6.09719567	0.99974726	23.807853	121.202798	25.459103	41.45
		±0.009099	±0.00001441	±0.00001129	±0.000785	±0.000045	±0.000086	±1.85
C/2010 D3	17060826	20100904.080190	4.24846025	0.99991442	304.623984	255.242399	76.358086	20.14
		±0.001039	±0.00000438	±0.00000502	±0.000137	±0.000010	±0.000022	±1.18
C/2010 R1	17050831	20120518.570947	5.62134619	0.99975559	114.531799	343.648214	156.925538	43.48
		±0.000333	±0.00000249	±0.00000290	±0.000037	±0.000017	±0.000004	±0.52

Appendix D: Part IV. Future barycentric orbital elements

Table D.1. Orbital elements of future barycentric orbits, i.e. after leaving the planetary zone for 28 near-parabolic comets described as sample A1 in Table A.1.

Comet (1)	Epoch [yyyymmdd] (2)	T [yyyymmdd.dddddd] (3)	q [au] (4)	e (5)	ω [°] (6)	Ω [°] (7)	i [°] (8)	$1/a_{\rm fut}$ [10^{-6} au^{-1}] (9)
			Future barycentric orbits based on the entire data sets					
C/1885 X1	21820810	18860407.057135	0.64058887	1.00006625	126.518354	38.136646	82.607618	−103.42
		±0.000133	±0.00000783	±0.00002647	±0.001336	±0.000094	±0.000459	±41.32
C/1892 Q1	21851013	18921228.159564	0.97762751	1.00047597	252.717846	265.987063	24.766253	−486.86
		±0.001086	±0.00000825	±0.00002276	±0.000772	±0.000186	±0.000149	±23.28
C/1952 W1	22500526	19530125.074189	0.77661881	1.00003215	253.740607	343.512621	97.122335	−41.39
		±0.002219	±0.00004215	±0.00008305	±0.004184	±0.000894	±0.000825	±106.94
C/1956 R1	22471228	19570408.428079	0.31297901	1.00018143	308.814505	216.076797	119.901340	−579.69
		±0.000086	±0.00000240	±0.00000312	±0.000342	±0.000070	±0.000054	±9.97
C/1959 Y1	22540505	19600321.174193	0.49958552	1.00014320	306.600044	252.749756	159.604537	−286.64
		±0.000469	±0.00001211	±0.00001678	±0.002240	±0.000630	±0.000206	±33.58
C/1974 F1	22830801	19750822.264925	3.01047419	0.99842815	261.338643	12.320071	50.625063	522.13
		±0.002042	±0.00001490	±0.00002048	±0.000526	±0.000091	±0.000059	±6.81
C/1978 H1	22660701	19781110.554368	1.14083841	1.00116958	231.489011	349.342113	43.677621	−1025.19
		±0.000446	±0.00000560	±0.00000931	±0.000411	±0.000060	±0.000085	±8.16
C/1986 P1	22941111	19870419.783953	1.20210995	0.99907772	238.307237	111.721429	147.193160	767.22
		±0.000120	±0.00000173	±0.00000282	±0.000142	±0.000040	±0.000028	±2.35
C/1989 Q1	22880416	19891112.554398	0.64134349	0.99994838	150.503378	275.566949	90.139972	80.49
		±0.000172	±0.00000894	±0.00001752	±0.001486	±0.000276	±0.000246	±27.32
C/1989 X1	22830403	19900410.752338	0.34950188	1.00012895	61.606028	75.873023	58.880721	−368.96
		±0.000035	±0.00000087	±0.00000189	±0.000126	±0.000017	±0.000065	±5.42
C/1990 K1	22800707	19901025.272025	0.93077116	1.00072380	242.432502	139.316414	131.505802	−777.63
		±0.000166	±0.00000836	±0.00000434	±0.000464	±0.000040	±0.000062	±4.66
C/1991 F2	22900116	19920120.599324	1.51751230	1.00014135	271.120029	11.863681	95.430183	−93.14
		±0.000348	±0.00000604	±0.00001110	±0.000370	±0.000048	±0.000085	±7.31
C/1992 J1	23011115	19930905.580473	3.00381947	0.99835796	83.330856	203.421098	124.406370	546.65
		±0.000215	±0.00000105	±0.00000281	±0.000042	±0.000020	±0.000019	±0.93

Notes. The successive columns signify (1) – comet designation, (2) – epoch, i.e. osculation date, (3) – perihelion time [TT], (4) – perihelion distance, (5) – eccentricity, (6) – argument of perihelion (in degrees), equinox 2000.0, (7) – longitude of the ascending node (in degrees), equinox 2000.0, (8) – inclination (in degrees), equinox 2000.0, (9) – inverse future semi-major axis in units of 10^{-6} au^{-1}.

Table D.1. continued.

Comet (1)	Epoch [yyyymmdd] (2)	T [yyyymmdd.dddddd] (3)	q [au] (4)	e (5)	ω [°] (6)	Ω [°] (7)	i [°] (8)	$1/a_{\rm fut}$ [10^{-6} au^{-1}] (9)
C/1993 A1	22890411	19940113.944023	1.93446946	1.00080747	130.706997	144.875683	124.890818	−417.41
		±0.000433	±0.00000563	±0.00000670	±0.000281	±0.000033	±0.000034	±3.46
C/1993 Q1	22900116	19940326.878309	0.96276580	1.00019695	260.876642	193.679026	104.969606	−204.56
		±0.000485	±0.00001197	±0.00002253	±0.001173	±0.000514	±0.000174	±23.40
C/1996 E1	22990728	19960729.365833	1.34394188	0.99950431	80.790883	149.918175	114.714647	368.83
		±0.000514	±0.00000722	±0.00000731	±0.000614	±0.000036	±0.000025	±5.44
C/1997 J2	23000213	19980311.767612	3.03930973	0.99995526	122.507863	148.804024	91.253220	14.72
		±0.000292	±0.00000168	±0.00000277	±0.000075	±0.000006	±0.000005	±0.91
C/1999 Y1	23070217	20010323.059698	3.08855418	0.99893231	184.115809	188.858728	134.822356	345.69
		±0.000391	±0.00000184	±0.00000450	±0.000082	±0.000016	±0.000023	±1.46
C/2001 B1	23010827	20000920.813403	2.91798483	1.00015681	284.691348	49.818261	104.116984	−53.74
		±0.000712	±0.00001360	±0.00000576	±0.000356	±0.000013	±0.000084	±1.97
C/2001 K3	23110207	20010423.011716	3.06103269	0.99796219	3.438725	289.773592	52.040007	665.73
		±0.001972	±0.00001205	±0.00002070	±0.000569	±0.000140	±0.000261	±6.77
C/2001 Q4	22941221	20040515.816463	0.96128328	1.00066754	1.204925	210.355822	99.556828	−694.43
		±0.000020	±0.00000017	±0.00000044	±0.000015	±0.000008	±0.000005	±0.46
C/2002 E2	22960414	20020222.046158	1.46932103	1.00064899	9.082564	244.579630	92.493100	−441.69
		±0.000226	±0.00000117	±0.00000410	±0.000082	±0.000030	±0.000011	±2.79
C/2002 Q5	22911127	20021119.865208	1.24128297	1.00111406	133.592966	34.114556	149.176788	−897.51
		±0.000034	±0.00000022	±0.00000137	±0.000044	±0.000043	±0.000010	±1.10
C/2002 T7	22940316	20040423.314758	0.61391053	1.00043817	158.241159	95.405415	160.442107	−713.73
		±0.000017	±0.00000040	±0.00000074	±0.000057	±0.000017	±0.000008	±1.20
C/2003 K4	23010827	20041013.151808	1.02157402	1.00012172	198.400305	18.727274	134.215507	−119.15
		±0.000033	±0.00000047	±0.00000078	±0.000037	±0.000009	±0.000009	±0.76
C/2003 T3	23120122	20040429.237972	1.47660706	0.99891046	43.671945	347.024324	50.489046	737.87
		±0.000046	±0.00000030	±0.00000104	±0.000017	±0.000017	±0.000015	±0.70
C/2004 B1	23000325	20060208.517477	1.59866036	1.00073763	327.900232	272.924965	114.086937	−461.40
		±0.000072	±0.00000069	±0.00000104	±0.000046	±0.000008	±0.000008	±0.65
C/2005 E2	22801110	20060220.925321	1.58157967	1.00398651	41.187815	347.820742	16.868082	−2520.59
		±0.000048	±0.00000112	±0.00000115	±0.000032	±0.000031	±0.000014	±0.73
			Future barycentric orbits based on DIST or post-perihelion data sets					
C/2001 Q4	22941221	20040515.816211	0.96129547	1.00067356	1.205484	210.355622	99.556892	−700.67
		±0.000057	±0.00000076	±0.00000074	±0.000046	±0.000015	±0.000007	±0.77
C/2002 T7	22950130	20040423.313348	0.61388642	1.00038541	158.237013	95.405068	160.441962	−627.82
		±0.000068	±0.00000073	±0.00000076	±0.000078	±0.000045	±0.000006	±1.23
C/2003 K4	23001230	20041013.162810	1.02158994	1.00018592	198.403591	18.727300	134.215649	−182.00
		±0.000728	±0.00000199	±0.00000261	±0.000193	±0.000021	±0.000022	±2.56

Table D.2. Orbital elements of future barycentric orbits, i.e. after leaving the planetary zone for 21 near-parabolic comets described as sample A2 in Table A.1 (comet C/2010 X1 disintegrated shortly after perihelion passage).

Comet (1)	Epoch [yyyymmdd] (2)	T [yyyymmdd.dddddd] (3)	q [au] (4)	e (5)	ω [°] (6)	Ω [°] (7)	i [°] (8)	$1/a_{\rm fut}$ [10^{-6} au^{-1}] (9)
		Future barycentric orbits based on the entire data sets						
C/2006 HW_{51}	23080212	20060929.188535	2.25852845	0.99979646	359.781513	228.103038	45.851873	90.12
		±0.000129	±0.00000068	±0.00000762	±0.000044	±0.000037	±0.000023	±3.37
C/2006 K3	23060622	20070313.561543	2.50568081	1.00032895	328.094463	49.406950	92.578493	−131.28
		±0.000802	±0.00000437	±0.00001170	±0.000239	±0.000028	±0.000053	±4.67
C/2006 L2	23050915	20061119.940263	1.99185210	1.00018974	47.969720	239.288007	101.012257	−95.26
		±0.000125	±0.00000070	±0.00000284	±0.000042	±0.000012	±0.000023	±1.43
C/2006 OF_2	23020315	20080915.318008	2.43768516	1.00160599	95.754006	318.447571	30.112628	−658.82
		±0.000048	±0.00000059	±0.00000055	±0.000024	±0.000007	±0.000004	±0.23
C/2006 P1	23090206	20070113.193081	0.17216685	0.99991949	156.045829	267.260532	78.000239	467.65
		±0.000040	±0.00000034	±0.00000062	±0.000052	±0.000025	±0.000025	±3.56
C/2006 Q1	23180311	20080704.341179	2.76008253	0.99804739	344.289869	199.476008	59.076619	707.44
		±0.000116	±0.00000072	±0.00000086	±0.000030	±0.000005	±0.000003	±0.31
C/2006 VZ_{13}	23110706	20070810.617405	1.01220890	0.99950280	174.033429	66.080220	134.788660	491.21
		±0.000466	±0.00000512	±0.00002034	±0.000460	±0.000025	±0.000155	±20.10
C/2007 N3	23170604	20090109.692209	1.21506856	0.99899255	136.783399	338.509220	178.373716	829.13
		±0.000041	±0.00000031	±0.00000076	±0.000110	±0.000108	±0.000005	±0.62
C/2007 O1	23030529	20070602.892064	2.86863333	1.00142522	159.219601	116.234733	24.398264	−496.83
		±0.000995	±0.00000764	±0.00001346	±0.000266	±0.000026	±0.000055	±4.69
C/2007 Q1	23030817	20061212.417182	3.00394882	1.00135141	282.497814	5.889648	82.243545	−449.88
		±0.748184	±0.02076805	±0.00223905	±0.531456	±0.067341	±0.245821	±741.49
C/2007 Q3	23110706	20091007.623842	2.25375096	0.99973190	2.092374	149.370279	65.647925	118.96
		±0.000160	±0.00000109	±0.00000215	±0.000061	±0.000009	±0.000009	±0.96
C/2007 W1	23120302	20080624.796026	0.84646901	0.99957598	306.418859	334.559057	9.892780	500.93
		±0.000144	±0.00000073	±0.00000362	±0.000076	±0.000033	±0.000013	±4.28
C/2007 W3	23111213	20080604.024147	1.76995312	0.99939133	112.491127	73.018628	78.669330	343.89
		±0.001179	±0.00001162	±0.00003203	±0.000801	±0.000218	±0.000180	±18.10
C/2008 A1	23091223	20080929.205406	1.06958685	0.99972575	348.352122	277.900996	82.577603	256.41
		±0.000085	±0.00000305	±0.00000239	±0.000179	±0.000025	±0.000015	±2.24
C/2008 C1	23121028	20080417.364965	1.26280553	0.99936537	180.915146	307.719067	61.828908	502.56
		±0.000264	±0.00000377	±0.00001486	±0.000311	±0.000153	±0.000068	±11.77
C/2008 J6	23021220	20080410.639100	2.00071646	1.00095973	10.606059	298.217398	44.988755	−479.69
		±0.000219	±0.00000280	±0.00000799	±0.000100	±0.000077	±0.000040	±4.00
C/2008 T2	23110303	20090614.090690	1.20126774	0.99966855	215.842430	309.656118	56.291580	275.92
		±0.000051	±0.00000063	±0.00000128	±0.000038	±0.000021	±0.000015	±1.06
C/2009 K5	23151014	20100430.285035	1.41994001	0.99921239	66.074823	257.913497	104.020049	554.68
		±0.000011	±0.00000009	±0.00000029	±0.000006	±0.000003	±0.000005	±0.20
C/2009 O4	23100307	20091231.874452	2.56213566	1.00015268	223.685205	172.979811	95.791209	−59.59
		±0.001067	±0.00000799	±0.00001256	±0.000349	±0.000026	±0.000156	±4.90
C/2009 R1	23090802	20100703.078964	0.40705236	0.99993062	130.727483	322.607146	77.010035	170.43
		±0.002045	±0.00002438	±0.00008029	±0.001900	±0.000130	±0.000107	±197.26
C/2010 H1	23180219	20100619.758327	2.74102522	0.99851734	233.759236	347.340145	36.506372	540.91
		±0.011996	±0.00007350	±0.00002949	±0.004490	±0.000510	±0.000733	±10.77
		Future barycentric orbits based on post-perihelion data sets						
C/2007 N3	23170604	20090109.694574	1.21506461	0.99899926	136.783798	338.509365	178.373715	823.61
		±0.000885	±0.00000449	±0.00000250	±0.000546	±0.000548	±0.000008	±2.06
C/2007 Q3	23110815	20091007.619323	2.25376856	0.99970301	2.092267	149.369798	65.648034	131.77
		±0.001618	±0.00001552	±0.00000817	±0.000334	±0.000110	±0.000025	±3.62
C/07W1 RN	23121028	20080624.794149	0.84649114	0.99953072	306.419508	334.558876	9.892613	554.38
		±0.000770	±0.00000555	±0.00000601	±0.000615	±0.000295	±0.000099	±7.09
C/2008 A1	23091113	20080929.208570	1.06952611	0.99973634	348.350303	277.900870	82.577708	246.52
		±0.000181	±0.00000546	±0.00000302	±0.000271	±0.000048	±0.000016	±2.82
C/2009 K5	23150904	20100430.285159	1.41994702	0.99921490	66.075141	257.913504	104.020021	552.91
		±0.000020	±0.00000055	±0.00000058	±0.000025	±0.000004	±0.000007	±0.41

Notes. The successive columns signify (1) – comet designation, (2) – epoch, i.e. osculation date, (3) – perihelion time [TT], (4) – perihelion distance, (5) – eccentricity, (6) – argument of perihelion (in degrees), equinox 2000.0, (7) – longitude of the ascending node (in degrees), equinox 2000.0, (8) – inclination (in degrees), equinox 2000.0, (9) – inverse future semi-major axis in units of 10^{-6} au^{-1}.

Table D.3. Orbital elements of future barycentric orbits, i.e. after leaving the planetary zone for 69 near-parabolic comets described as sample B in Table A.1.

Comet (1)	Epoch [yyyymmdd] (2)	T [yyyymmdd.dddddd] (3)	q [au] (4)	e (5)	ω [°] (6)	Ω [°] (7)	i [°] (8)	$1/a_{\rm fut}$ [10^{-6} au^{-1}] (9)
C/1972 L1	22691122	19721113.990154	4.27440651	1.00265385	56.572391	225.472679	79.414662	−620.87
		±0.003911	±0.00001806	±0.00002653	±0.000589	±0.000117	±0.000072	±6.20
C/1973 W1	22750624	19730810.219208	3.84312446	1.00041071	221.296365	244.622483	108.018234	−106.87
		±0.006610	±0.00008654	±0.00004732	±0.002035	±0.000278	±0.000096	±12.31
C/1974 V1	22880705	19740806.921353	6.01222855	0.99654636	151.677213	226.099858	60.909106	574.44
		±0.019374	±0.00009311	±0.00007283	±0.001868	±0.000068	±0.000199	±12.12
C/1976 D2	22840108	19750115.363704	6.88351258	0.99962729	193.402971	22.777758	111.985520	54.15
		±0.013254	±0.00010053	±0.00005033	±0.001460	±0.000180	±0.000138	±7.31
C/1976 U1	22850611	19760707.800353	5.85826685	0.99884526	118.887188	286.007941	86.681367	197.11
		±0.036004	±0.00014138	±0.00012806	±0.003900	±0.000292	±0.000352	±21.86
C/1978 A1	22820806	19770722.474789	5.60423856	1.00054560	343.329066	211.703824	116.917447	−97.35
		±0.006619	±0.00003826	±0.00006660	±0.000535	±0.000068	±0.000161	±11.88
C/1978 G2	22841014	19780825.628227	6.27935179	1.00062275	229.662065	72.306967	153.149555	−99.17
		±0.027360	±0.00026690	±0.00023752	±0.002455	±0.000450	±0.000233	±37.82
C/1979 M3	22820627	19790715.830345	4.69259184	1.00068015	10.170728	293.148018	92.100795	−144.94
		±0.011056	±0.00004319	±0.00006823	±0.001486	±0.000083	±0.000337	±14.54
C/1980 E1	21900410	19820311.710422	3.35597902	1.05373351	134.961421	114.562873	1.661948	−16011.28
		±0.001095	±0.00001203	±0.00000942	±0.000948	±0.000896	±0.000025	±2.77
C/1983 O1	22830910	19830722.539563	3.32055481	1.00062077	186.331396	209.664462	134.633032	−186.95
		±0.001245	±0.00001296	±0.00000692	±0.000353	±0.000047	±0.000037	±2.08
C/1984 W2	22881102	19850930.147908	3.99720363	1.00012613	255.274852	250.173500	89.247736	−31.55
		±0.005056	±0.00004937	±0.00003425	±0.001094	±0.000102	±0.000096	±8.57
C/1987 F1	22920106	19870409.819196	3.62589912	0.99936819	329.012173	194.474308	124.059494	174.25
		±0.002347	±0.00001498	±0.00001802	±0.000450	±0.000055	±0.000076	±4.97
C/1987 H1	22921012	19861115.095110	5.45463641	1.00003125	16.842456	268.319709	132.491937	−5.73
		±0.004087	±0.00003115	±0.00001546	±0.000555	±0.000078	±0.000056	±2.83
C/1987 W3	22860318	19880118.036179	3.32893198	1.00120357	194.587361	198.345776	76.707904	−361.55
		±0.002735	±0.00001617	±0.00002420	±0.000546	±0.000087	±0.000095	±7.27
C/1988 B1	22910220	19870319.919988	5.03103521	1.00054965	124.175688	325.180830	80.574313	−109.25
		±0.009039	±0.00007221	±0.00003515	±0.001327	±0.000038	±0.000138	±6.99
C/1993 F1	22950311	19920805.102586	5.89952519	1.00209959	61.996503	77.463429	53.959731	−355.89
		±0.010526	±0.00006916	±0.00003704	±0.001165	±0.000132	±0.000050	±6.27
C/1993 K1	23060403	19940201.616244	4.84606419	0.99711750	232.375367	30.352470	67.825586	594.81
		±0.003885	±0.00002497	±0.00003713	±0.000468	±0.000102	±0.000070	±7.66
C/1997 A1	22961031	19970621.802449	3.15501004	1.00071733	40.095287	135.813600	144.984535	−227.36
		±0.000517	±0.00000235	±0.00000517	±0.000114	±0.000018	±0.000027	±1.64
C/1997 BA$_6$	23070217	19991128.384619	3.43278727	0.99861836	285.874864	317.586592	72.674074	402.48
		±0.000943	±0.00000591	±0.00000589	±0.000187	±0.000014	±0.000023	±1.72
C/1999 F1	23081228	20020214.775850	5.78376567	0.99982188	255.166558	20.001696	91.989935	30.80
		±0.000569	±0.00000235	±0.00000343	±0.000041	±0.000011	±0.000014	±0.59
C/1999 F2	23070617	19980824.046090	4.72526742	0.99834836	352.417408	210.225871	56.402618	349.53
		±0.002597	±0.00001504	±0.00001569	±0.000351	±0.000051	±0.000050	±3.32
C/1999 H3	23020203	19990817.978459	3.50201708	1.00003511	101.885230	332.815367	115.893722	−10.02
		±0.000410	±0.00000330	±0.00000368	±0.000090	±0.000010	±0.000015	±1.05
C/1999 J2	23080103	20000405.791060	7.11244479	1.00061909	127.109177	50.076690	86.364147	−87.04
		±0.000913	±0.00000475	±0.00000460	±0.000063	±0.000011	±0.000009	±0.65
C/1999 K5	23070217	20000704.013847	3.26343066	0.99874785	241.555903	106.352565	89.570567	383.69
		±0.000326	±0.00000093	±0.00000310	±0.000043	±0.000011	±0.000024	±0.95
C/1999 N4	23060910	20000522.058157	5.51244642	0.99985465	90.432807	345.955755	156.948399	26.37
		±0.000849	±0.00000630	±0.00000787	±0.000099	±0.000046	±0.000009	±1.43
C/1999 S2	23011006	19971121.877189	6.46116610	1.00207639	223.382735	74.395135	65.865297	−321.37
		±0.006539	±0.00004892	±0.00002446	±0.000623	±0.000142	±0.000028	±3.79
C/1999 U1	23081009	19980903.430110	4.12996080	0.99777930	290.958233	58.287371	105.882515	537.70
		±0.003442	±0.00002416	±0.00001238	±0.000631	±0.000024	±0.000122	±3.00
C/1999 U4	23030529	20011026.980430	4.90968719	1.00143976	77.397331	32.273045	51.997123	−293.25
		±0.000244	±0.00000136	±0.00000263	±0.000024	±0.000011	±0.000009	±0.54
C/2000 A1	23140908	20000713.185351	9.74225531	0.99927460	14.319745	111.847687	24.549661	74.46
		±0.011047	±0.00002926	±0.00001927	±0.000504	±0.000041	±0.000049	±1.98

Notes. All future orbits in this table are based on the osculating orbits determined from the entire data sets. The successive columns signify (1) – comet designation, (2) – epoch, i.e. osculation date, (3) – perihelion time [TT], (4) – perihelion distance, (5) – eccentricity, (6) – argument of perihelion (in degrees), equinox 2000.0, (7) – longitude of the ascending node (in degrees), equinox 2000.0, (8) – inclination (in degrees), equinox 2000.0, (9) – inverse future semi-major axis in units of 10^{-6} au^{-1}.

Table D.3. continued.

Comet	Epoch [yyyymmdd]	T [yyyymmdd.dddddd]	q [au]	e	ω [°]	Ω [°]	i [°]	$1/a_{\rm fut}$ [10^{-6} au^{-1}]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
C/2000 CT_{54}	23100601	20010620.167758	3.15378664	0.99815414	272.617606	18.898590	49.175381	585.28
		±0.001071	±0.00001050	±0.00000798	±0.000300	±0.000019	±0.000041	±2.53
C/2000 K1	23081118	19991213.783393	6.28089295	0.99913582	15.726080	260.150800	116.769737	137.59
		±0.002328	±0.00001466	±0.00001454	±0.000216	±0.000028	±0.000038	±2.32
C/2000 O1	23080502	20000127.073362	5.91375918	0.99925104	55.131151	88.950073	148.085030	126.65
		±0.003379	±0.00002654	±0.00002809	±0.000314	±0.000115	±0.000040	±4.75
C/2000 SV_{74}	23040413	20020429.659239	3.53676676	1.00019411	76.072949	24.187913	75.352526	−54.88
		±0.000299	±0.00000223	±0.00000212	±0.000063	±0.000010	±0.000009	±0.60
C/2000 Y1	23110417	20010131.885868	7.96565179	0.99998723	181.639132	239.409922	137.998707	1.60
		±0.012405	±0.00004716	±0.00003373	±0.000763	±0.000036	±0.000103	±4.23
C/2001 C1	23050118	20020328.849382	5.10851053	1.00109569	220.006765	33.711913	68.913424	−214.48
		±0.002426	±0.00001163	±0.00001070	±0.000276	±0.000013	±0.000050	±2.09
C/2001 G1	23110308	20011009.975832	8.23579001	1.00086239	343.306947	203.917759	45.353710	−104.71
		±0.008222	±0.00003120	±0.00002267	±0.000465	±0.000024	±0.000043	±2.75
C/2001 K5	23070217	20021012.477784	5.18717324	1.00049165	47.114383	237.451142	72.550141	−94.78
		±0.000226	±0.00000144	±0.00000210	±0.000023	±0.000006	±0.000005	±0.41
C/2002 A3	24491208	20020419.461060	5.14743062	0.96822207	329.358358	136.410260	48.563937	6173.55
		±0.003121	±0.00000811	±0.00000991	±0.000346	±0.000010	±0.000018	±1.93
C/2002 J4	23030708	20031003.306849	3.63811716	1.00098246	230.766608	70.872660	46.480076	−270.05
		±0.000243	±0.00000106	±0.00000360	±0.000036	±0.000015	±0.000016	±0.99
C/2002 J5	23100422	20030920.575808	5.73013639	0.99992376	74.912592	314.086941	117.190377	13.30
		±0.000426	±0.00000291	±0.00000388	±0.000039	±0.000013	±0.000007	±0.68
C/2002 L9	23131023	20040406.791856	7.03670088	0.99945273	231.480567	110.436611	68.407644	77.77
		±0.000764	±0.00000604	±0.00000627	±0.000050	±0.000011	±0.000011	±0.89
C/2002 R3	23060910	20030612.238091	3.87294504	0.99998505	44.982189	54.297596	161.114685	3.86
		±0.002420	±0.00000705	±0.00002452	±0.000475	±0.000181	±0.000029	±6.33
C/2003 G1	23031105	20030204.318059	4.92097111	1.00183398	11.495253	246.108010	66.818784	−372.69
		±0.000634	±0.00000351	±0.00000313	±0.000092	±0.000010	±0.000017	±0.64
C/2003 S3	23130804	20030408.011228	8.12368438	1.00005949	154.403211	226.380197	151.491334	−7.32
		±0.004310	±0.00003134	±0.00002426	±0.000245	±0.000036	±0.000030	±2.99
C/2003 WT_{42}	23140220	20060410.407036	5.18238436	0.99896550	92.354949	48.405111	31.423890	199.62
		±0.000184	±0.00000116	±0.00000168	±0.000021	±0.000008	±0.000003	±0.32
C/2004 P1	23090606	20030809.402431	6.01959208	1.00053526	16.663610	284.176723	28.802090	−88.92
		±0.006324	±0.00003012	±0.00001833	±0.000687	±0.000240	±0.000095	±3.05
C/2004 T3	23151122	20030416.040415	8.86447368	0.99933897	259.687490	50.384035	71.931989	74.57
		±0.024562	±0.00008464	±0.00003725	±0.001642	±0.000134	±0.000050	±4.20
C/2004 X3	23020603	20050616.645926	4.39810248	1.00281265	202.017151	343.041981	81.093110	−639.51
		±0.001397	±0.00000560	±0.00000933	±0.000206	±0.000014	±0.000081	±2.12
C/2005 B1	23101218	20060223.968560	3.20473676	0.99923378	103.142507	195.599965	92.535516	239.09
		±0.000262	±0.00000163	±0.00000209	±0.000064	±0.000010	±0.000017	±0.65
C/2005 EL_{173}	23100313	20070305.948169	3.88766749	1.00007433	261.461335	344.826942	130.732213	−19.12
		±0.000563	±0.00000364	±0.00000354	±0.000111	±0.000009	±0.000008	±0.91
C/2005 G1	23111103	20060227.214273	4.95699500	0.99976267	113.727471	299.558608	108.370283	47.88
		±0.000986	±0.00000428	±0.00000506	±0.000118	±0.000029	±0.000010	±1.02
C/2005 K1	23071015	20051121.746277	3.68630111	1.00029483	134.829785	106.358493	77.794144	−79.98
		±0.001318	±0.00000635	±0.00001140	±0.000238	±0.000024	±0.000012	±3.09
C/2005 L3	23171002	20080114.821598	5.58874050	0.99836758	47.063435	288.804398	139.445843	292.09
		±0.000088	±0.00000040	±0.00000070	±0.000009	±0.000004	±0.000002	±0.13
C/2005 Q1	23120411	20050824.863594	6.40857612	1.00049664	44.604432	87.698097	105.212368	−77.50
		±0.003613	±0.00001269	±0.00001311	±0.000316	±0.000045	±0.000033	±2.05
C/2006 E1	23130625	20070106.081932	6.03851059	1.00026161	232.757255	95.076335	83.187785	−43.32
		±0.002793	±0.00001093	±0.00001350	±0.000230	±0.000036	±0.000048	±2.24
C/2006 K1	23070905	20070720.594029	4.42802761	1.00156044	296.450187	72.134583	53.846964	−352.40
		±0.000339	±0.00000227	±0.00000410	±0.000042	±0.000010	±0.000009	±0.93
C/2006 S2	23090318	20070507.460166	3.15535756	1.00003397	166.235774	113.952733	98.991350	−10.77
		±0.009306	±0.00001606	±0.00005708	±0.002563	±0.000032	±0.000056	±18.09
C/2006 S3	23170316	20120415.080141	5.13281311	1.00020156	140.121259	38.447592	166.034249	−39.27
		±0.000111	±0.00000064	±0.00000083	±0.000016	±0.000011	±0.000003	±0.16
C/2006 YC	23161226	20060911.244477	4.94218283	0.99783934	335.365069	154.232162	69.573037	437.19
		±0.031483	±0.00013842	±0.00005959	±0.004359	±0.000120	±0.001628	±12.07
C/2007 D1	23280626	20070614.544250	8.78831161	0.99351095	339.973968	171.029787	41.507970	738.37
		±0.002784	±0.00001367	±0.00000831	±0.000144	±0.000008	±0.000014	±0.95

Table D.3. continued.

Comet	Epoch [yyyymmdd]	T [yyyymmdd.dddddd]	q [au]	e	ω [°]	Ω [°]	i [°]	$1/a_{fut}$ [10^{-6} au^{-1}]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
C/2007 JA_{21}	23120630	20061115.447846	5.36244677	1.00004874	93.664982	65.497273	89.861157	−9.09
		±0.003187	±0.00001766	±0.00001072	±0.000396	±0.000030	±0.000022	±2.00
C/2007 Y1	23131023	20080319.404978	3.34318656	0.99904941	357.056538	133.054513	110.169228	284.34
		±0.002263	±0.00001678	±0.00004165	±0.000534	±0.000092	±0.000361	±12.46
C/2007 VO_{53}	23160719	20100425.734230	4.84554239	0.99941804	75.037730	59.726727	86.999341	120.10
		±0.000202	±0.00000117	±0.00000173	±0.000023	±0.000007	±0.000006	±0.36
C/2008 FK_{75}	23140220	20100930.240221	4.50757790	1.00036763	80.408938	218.247705	61.190721	−81.56
		±0.000095	±0.00000057	±0.00000112	±0.000012	±0.000004	±0.000003	±0.25
C/2008 P1	23150725	20090722.386462	3.89265287	0.99906391	11.780623	357.715831	64.320996	240.48
		±0.000239	±0.00000102	±0.00000214	±0.000039	±0.000005	±0.000009	±0.55
C/2009 P2	23180709	20100210.745514	6.54247976	0.99968814	76.230546	60.497239	163.451272	47.67
		±0.001296	±0.00000888	±0.00000906	±0.000126	±0.000066	±0.000011	±1.39
C/2009 U5	23141018	20100622.526457	6.10059323	1.00138990	24.000202	121.012427	25.467175	−227.83
		±0.009063	±0.00001434	±0.00001129	±0.000782	±0.000047	±0.000086	±1.85
C/2010 D3	23161007	20100904.425117	4.24461582	0.99919099	304.568634	255.203753	76.374021	190.60
		±0.001013	±0.00000435	±0.00000502	±0.000138	±0.000010	±0.000023	±1.18
C/2010 R1	23190704	20120518.214822	5.62509170	0.99957374	114.528021	343.702395	156.950481	75.78
		±0.000333	±0.00000250	±0.00000290	±0.000037	±0.000017	±0.000004	±0.52