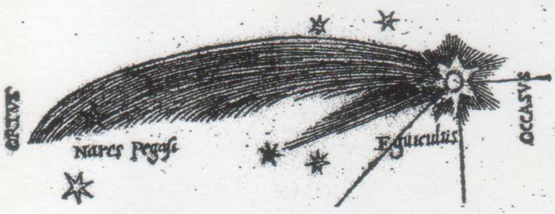
International Comet Quarterly



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— Table of Contents —

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The International Comet Quarterly (*ICQ*) is a journal devoted to news and observation of comets, published by the Cometary Science Center at the Department of Earth and Planetary Sciences at Harvard University in Cambridge, Massachusetts. Regular issues are published 4 times per year (January, April, July, and October), with an annual *Comet Handbook* of ephemerides published normally in the first half of the year as a special fifth issue. An index to each volume normally is published in every other October issue (now in odd-numbered years); the *ICQ* is also indexed in *Astronomy and Astrophysics Abstracts* and in *Science Abstracts Section A*.

The regular (invoiced) subscription rate is US$60.00 per year for North American and for overseas surface-mail delivery (price includes the annual *Comet Handbook*; the price without the *Handbook* is US$45.00 per year). Subscribers who do not wish to be billed may subscribe at the special rate of US$45.00 per year for surface-mail delivery (rate is $30.00 without *Handbook*). Add $30.00/year to each of these rates for overseas airmail delivery. These rates became valid as of Nov. 2007. [The last set of digits (after the hyphen) on the top line of the mailing address label gives the Whole Number that signifies the last *ICQ* issue which will be sent under the current subscription status. An asterisk after these numbers indicates credit for the next annual Comet Handbook. The first five digits represent the subscriber's account number.] Subscribers should now send checks or money orders (payable in U.S. funds to "International Comet Quarterly" and drawn on a U.S. bank) to the following new full postal address: Dr. Daniel W. E. Green, *ICQ* Editor; Hoffman Lab 209; Harvard University; 20 Oxford St.; Cambridge, MA 02138; U.S.A. Credit-card payments may also be made; contact the editor for further information.

Manuscripts will be reviewed/refereed for possible publication; authors should first obtain a copy of "Information and Guidelines for Authors" from the *ICQ* website or from the Editor. Cometary observations should be sent to the Editor in Cambridge; again, see the *ICQ* website or contact the Editor for the proper format. Those who can send observational data (or manuscripts) in machine-readable form are encouraged to do so [especially through e-mail via the Internet (ICQCSC@EPS.HARVARD.EDU)]. The *ICQ* has extensive information for comet observers on the World Wide Web, including the Keys to Abbreviations used in data tabulation (see URL http://www.cfa.harvard.edu/icq/icq.html). The *ICQ* published a 225-page *Guide to Observing Comets* in early 1997 that is now out of print; a revised edition is in preparation.

Most of the Observation Coordinators (OCs) listed below have e-mail contacts with the *ICQ* Editor; observers in the general area of such OCs who lack access to e-mail networks may send data to the OC for relay to the *ICQ* in electronic form.

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From the Editor

As noted in the last issue, after thirty years of being based at the Harvard-Smithsonian Center for Astrophysics, the *ICQ* and its Editor have moved to the Department of Earth and Planetary Sciences at Harvard University. Please note the new postal and e-mail addresses. Subscriptions are longer accepted by the Smithsonian Astrophysical Observatory; subscribers can send checks or money orders to the new postal address above, and credit-card payments can be made via a new secure webpage.

The move has been very time-consuming, and it forced us to begin using new computers in the second half of 2010. We are grateful to the Tamkin Foundation for providing a grant to purchase new computers for the Cometary Science Center/Laboratory/Archive (which now published the *ICQ* at the EPS Department, Harvard). The process of setting up the new computers and copying data over from the old computers has taken many months, as has the establishment of subscriptions at (and transferral from SAO to) the new location. Unfortunately, this (together with time taken to seek additional outside funding for the new Center) has caused a considerable delay in publishing the *ICQ*. We now are working to get all of the 2010 issues published and distributed in the next couple of months, and plan to be caught up by mid-2011.

Note that the *2010/2011 Comet Handbook* was published several months ago, and the *2011/2012 Comet Handbook* is to be published also in mid-2011.

We thank our readers for their patience and continued support. — *D. W. E. Green*

Recurrence of Super-Massive Explosions and Orbital Evolution of Comet 17P/Holmes: II. Search for Historical Records, and Outlook for Future Research

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Abstract. *Based on the results of Part I of this study, historical records are searched for possible observations of comet 17P/Holmes undergoing super-massive explosions. A major objective is to establish whether the two episodes of the 1892-1893 event and the megaburst of 2007 were accidental or diagnostic of a systematic long-term pattern. The comet's reference orbit (cf. Part I) has been integrated back in time to ~ 1000 BC, indicating that comet 17P repeatedly underwent close encounters with Jupiter, the result of which has been a gradual reduction of the orbital dimensions and period. A search ephemeris has been calculated and applied in comprehensively testing the historical records to determine — from the timing, the location in the sky, and the physical appearance of archived objects — pre-1892 instances of probable naked-eye detection of comet 17P during or shortly after a super-massive explosion. Attractive candidates include objects classified as dubious novae. A two-step search procedure has resulted in identifying four events as possible appearances of 17P: May 1621, August 1269, July-August 836, and September-October 305, this earliest one being the most promising instance. Forward integration of the reference orbit is used in part to probe the observing conditions during the comet's next return to perihelion in 2014.*

1. Introduction

Comet 17P/Holmes is the only comet known to have *repeatedly* undergone super-massive explosions, violent events of a relatively short duration (typically lasting a few days) but of global proportions on the scale of the nucleus, involving several km^2 of the surface. During each such event, a mass of 10^{13} to 10^{14} grams of microscopic dust is injected into the atmosphere and the comet becomes temporarily a naked-eye object, initially of starlike appearance, that develops into a round, sharply-bounded dust halo uniformly expanding at a subkilometer-per-second velocity for days, weeks, or even longer after the termination of an active phase. I introduced the term "super-massive explosions" (Sekanina 2008a) to distinguish these events from ordinary outbursts that involve dust masses not greater than 10^{12} grams, originate in fairly small areas of the nuclear surface, and occur frequently.

I have undertaken a comprehensive investigation of comet 17P/Holmes and have compared the properties of the two super-massive explosions that occurred 115 years apart — the two episodes of the 1892-1893 event and the megaburst of 2007 (Sekanina 2008b; 2009a). In Part I of this investigation (Sekanina 2009b, referred to hereafter as Paper 1), I studied extensively the comet's history of observation between the time of discovery in 1892 and the present time. I examined the possibility that additional super-massive explosions occurred between the two reported ones and the chances that they remained undetected, especially during the comet's seven missed returns to perihelion between 1913 and 1957. I concluded that there was no evidence — and a near-zero probability — of any such additional explosion taking place during the intervening 115 years. One can practically rule out recurring of super-massive explosions of comet 17P on a time scale much shorter than a century or so.

Next, I developed a comprehensive physical model for the super-massive explosions (Sekanina 2009c, referred to hereafter as Paper 2), adopting 17P as an example of comets whose nuclei are thought to consist of "layered" morphology, as illustrated by comet 9/Tempel in close-up images taken with the camera onboard the impactor of the Deep Impact mission (Thomas *et al.* 2007). A "super-massive explosion" is described in Paper 2 as a sudden release, from the nucleus, of a terrain layer tens of meters thick and several km^2 in areal extent that collapses upon liftoff into a cloud of mostly microscopic dust. The triggering mechanism is identified with an exothermic transformation of water ice from amorphous phase to cubic phase, a runaway, temperature-driven process activated by conduction of the solar energy from the surface into the interior of the nucleus. The water ice is stored in a reservoir beneath the layer, with superheated, highly volatile gases (such as carbon monoxide) trapped inside. The enormous momentum required for the layer's jettisoning is provided in part by the energy released by the phase change, but primarily by the superheated gases that escape from the ice upon its crystallization. The recurrence of super-massive explosions was employed in the proposed scenario for 17P in Paper 2 as a tool for modeling heat transfer in the interior of the nucleus, with the span of 115 years between the two events employed as a constraint for estimating an effective thermal conductivity of porous granular material that is thought to make up such terrain layers.

2. The Objectives, Orbital Motion of Comet 17P, and Error Propagation

From the nature of the proposed physical model, it was unequivocally concluded in Paper 2 that the recurrence time of super-massive explosions of comet 17P/Holmes may under no circumstances be understood as a strict periodicity. Besides, if the propensity of 17P (and apparently other comets as well; see Sekanina 2008a) for these violent events is rooted in continual removal of terrain layers, one by one, from the nucleus, then this process should proceed over very long periods of time, at least centuries or millennia, and records of the repeatedly exploding comet that temporarily becomes a naked-eye object may appear in old chronicles and annals.

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Table 1. Reference orbit JPL K077/21 for comet 17P/Holmes (equinox J2000.0).[a]

Osculation epoch (ET)	2007 May 20.0
Time of perihelion passage (ET)	2007 May 4.49672 ± 0.00011
Argument of perihelion (deg)	24.257660 ± 0.000047
Longitude of ascending node (deg)	326.867443 ± 0.000037
Orbit inclination (deg)	19.113149 ± 0.000005
Perihelion distance (AU)	2.05316182 ± 0.00000095
Orbit eccentricity	0.43243078 ± 0.00000026
Orbital period (yr)	6.88
Nongravitational parameters:	
Radial component A_1 (10^{-8} AU day^{-2})	+0.24754 ± 0.00488
Transverse component A_2 (10^{-8} AU day^{-2})	+0.03124 ± 0.00025
Orbital arc covered by observations	1964 Jul. 16 — 2009 Mar. 25
Length of time interval (days)	16,323
Number of linked apparitions	7
Number of observations	3581
Mean residual (arcsec)	±0.68

[a] See Mastrodemos (2009). The Ephemeris Time, ET, is a generic term used throughout this paper for a uniform time scale (see Sec. 3 for comments and conversion to the Universal Time, UT).

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The main objectives of this paper are a systematic search, in such historical sources, for possible records on comet 17P and its likely identification based on diagnostic data. The necessary prerequisite for this effort is the availability of reasonably accurate information on the orbital evolution of the comet over long periods of time. The arguments, in Paper 1, for choosing a reference JPL orbit K077/21 (Mastrodemos 2009) — derived by fitting nearly 3600 astrometric observations between 1964 and 2009 — as the best match to the comet's motion from 1892 on, now also support a decision to use this set of elements, reproduced in Table 1, as the basis for predicting the comet's orbital evolution over a more extended span of time. For an orbit of fairly stable dimensions and spatial orientation, a *nominal* error that, due to orbital integration, propagates in the time of perihelion passage t_π after n revolutions about the sun reckoned from the nearest apparition used in the orbit determination, can be estimated from

$$\epsilon_n(t_\pi) = \frac{1}{2} n(n+1) \langle P(t_\pi) \rangle \psi, \qquad (1)$$

where $\langle P(t_\pi) \rangle = (t_\pi^\star - t_\pi)/n$ is the mean reference orbital period at the perihelion time t_π, $t_\pi^\star = 1964.87$ is the perihelion time in 1964 (the earliest return used in deriving the reference orbit), from which $\langle P \rangle$ for any t_π is reckoned, and ψ is a dimensionless factor numerically equal to an estimated relative error in the orbital period. From Sec. 4 and Table 2 of Paper 1 it follows that ψ in Eq. (1) can reliably be calibrated by the results for the 1899 apparition of comet 17P. The three best orbit determinations based on the observations including those from 1899 (Zwiers 1902, 1905; Koebcke 1948; Williams 1999) leave (as seen in column 3 of that table) the perihelion-time differences from the reference orbit of, respectively, 0.010, 0.010, and 0.006 day (in absolute value), or 0.009 day on the average. The number of revolutions back in time from 1964 to 1899 is $n = 9$ and the mean integrated orbital period in this time interval is $\langle P(1899) \rangle = 7.28$ years $= 2660$ days, so that the error in the perihelion time (in days) propagated to the 1899 return is $\epsilon_9(1899) = \pm\, 0.009 = \frac{1}{2} \times 9 \times 10 \times 2660 \times \psi$, or $\psi = \pm\, 0.75 \times 10^{-7}$. Equation (1) predicts that, on the assumption of a relatively stable orbit ($\langle P \rangle \simeq$ const.), the integration of the reference set of elements back in time leads to an estimated error in the perihelion time of ±0.4 day in AD 1500, ±2 days in AD 1000, ±7 days at the beginning of the Christian calendar, and ±17 days around 1000 BC, an extreme limit to which it is feasible to carry out the orbit integration, given the exceedingly incomplete and fragmentary statistics of earlier historical records.

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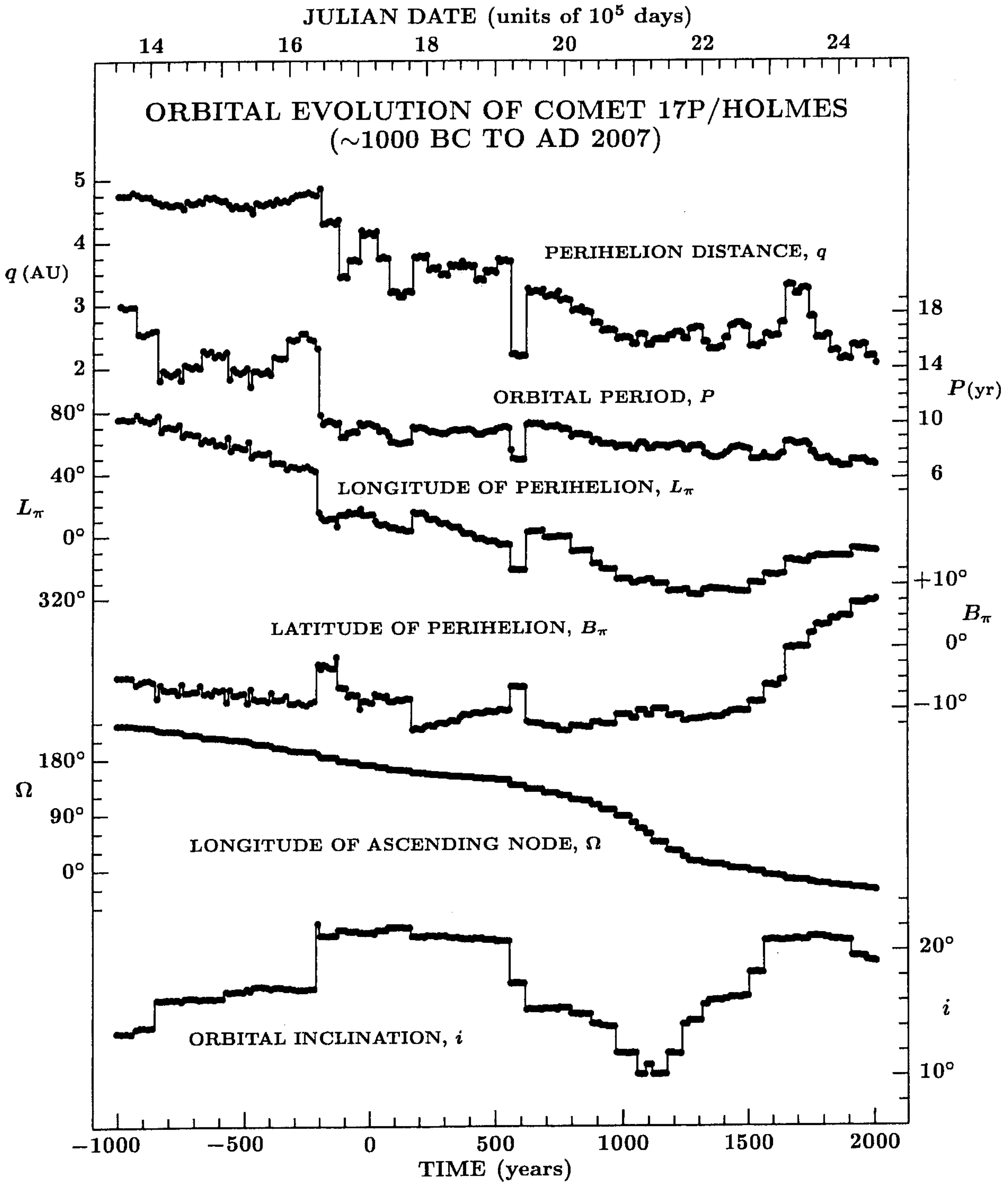

Figure 1. Orbital variations of comet 17P/Holmes calculated for the past three millennia from the reference orbit. Sudden major changes seen in the plots of six orbital parameters indicate instances of major perturbations by Jupiter. Rapid decreases in the orbital dimensions and period, the regression of the nodal line and the steplike variations in the inclination are clearly apparent.

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The actual integration of the reference set of elements shows a very complex orbital evolution of comet 17P/Holmes over the past three millenia, as seen from Figure 1. The main features are (i) numerous bumps on five of the six plotted parameters, indicating instances of major orbital perturbations by Jupiter; (ii) a striking reduction in the perihelion distance with time, from almost 5 AU near 1000 BC to about 2 AU today, implying an average rate of decrease of ~ 1 AU per millennium; (iii) an equally dramatic shortening of the orbital period, especially a precipitous drop from 16.1

to 11.3 years near 215 BC; (iv) an unusually rapid motion of the line of apsides; and (v) two flat peaks in the inclination distribution, with a sharp minimum in between, around AD 1100.

The striking orbital changes displayed in Figure 1 have a major impact on the objectives of this paper (Sec. 3). The greater perihelion distance and longer orbital period in the distant past mean that heat transport through the interior of the nucleus must have proceeded much more slowly in those times, especially before AD 560. The bump between 1650 and 1740 could also cause an anomaly in the rate of super-massive explosions in that period of time. The changes in the orbital period and dimensions necessarily affect the rate of error propagation, and the times of perihelion passage calculated by orbital integration back in time are surely determined much less accurately than predicted by Eq. (1). The variable direction of the line of apsides is bound to contribute to an obliquity instability and thus to changes in the insolation regime, which is also affected by the steplike perturbations in the inclination and by the steady regression of the nodal line. These insolation variations over the surface of the nucleus ought to have an effect on the nongravitational parameters. A detailed search ephemeris (Sec. 3) will allow one to realistically estimate the influence of all these orbital changes on the comet's position in the sky as a function of the time from perihelion over many revolutions about the sun.

Table 2 summarizes the calculated changes in the perihelion distance and orbital period (reckoned from perihelion to next perihelion) of comet 17P/Holmes over the past nearly three millennia. Except in the angular elements, the comet's orbit was relatively stable for more than seven centuries, between the years 916 and 1644. With the exception of the returns 1652 to 1738, the perihelion distance is seen to have remained below 3 AU since the very end of the 8th century; it has stayed below 4 AU since AD 28. Also since this same time, the orbital period has remained below 10 years. Table 2 further shows that the mean reference period $\langle P \rangle$, affecting the error propagation in the perihelion time, has stayed below 10 years ever since the year −1004 (or 1005 BC) and has essentially been a steadily decreasing function of time.

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Table 2. Predicted variations in the perihelion distance and orbital period of comet 17P/Holmes between the returns 1892 and −1004.[a]

Returns to sun	Range of perihelion distances (AU)	Mean orbital period[b] (yr)	Mean reference period[c] (yr)	Number of returns[d] to sun
1829 to 1892	2.1 to 2.3	7.0	7.1	10
1747 to 1822	2.4 to 2.9	7.5	7.3	11
1652 to 1738	3.1 to 3.4	8.6	7.6	11
1628 to 1644	2.7 to 2.8	7.8	7.6	3
916 to 1620	2.2 to 2.7	8.1	7.9	88
799 to 908	2.7 to 3.0	9.1	8.0	13
622 to 790	3.0 to 3.3	9.8	8.2	18
560 to 612	2.1 to 2.3	7.4	8.2	8
171 to 552	3.3 to 3.8	9.5	8.5	41
75 to 162	3.1 to 3.3	8.7	8.5	11
28 to 66	3.7 to 3.8	9.5	8.5	5
−42 to 18	4.1 to 4.2	10.0	8.5	7
−126 to −52	3.4 to 3.8	9.3	8.6	9
−1004 to −136	4.2 to 4.9	14.5	9.7	61

[a] For comparison, for the 17 returns 1892 through 2007 the range of perihelion distances was 2.0 to 2.4 AU and the mean orbital and reference periods were both 7.2 years.

[b] From difference between perihelion times of the starting and ending returns.

[c] From difference between perihelion times of the starting return and the 1964 return.

[d] Including the starting and ending returns.

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Table 3 lists the nominal perihelion times between AD 1885 (the return immediately preceding the discovery apparition of 1892) and 1005 BC calculated by integrating the reference orbit back in time. There are 295 perihelion passages during this period of time. Both sudden orbital changes during close approaches to Jupiter and a lower orbital eccentricity necessarily lead to greater uncertainties in the perihelion times (as well as other elements) than predicted on a stable-orbit assumption. To account approximately for these inaccuracies, Eq. (1) has been modified to estimate an *effective* error propagating in the perihelion time,

$$\epsilon_n^*(t_\pi) = \frac{1}{2}(N+10)(N+11)\langle P(t_\pi)\rangle\,\psi^*, \tag{2}$$

where n, the actual number of revolutions reckoned from the 1964 apparition, is expressed in terms of the return number, N (from Table 2), which has been augmented by 10 (the number of revolutions between 1964 and 1892), and the normalization constant is estimated at $\psi^* \simeq 10\psi = \pm 0.75 \times 10^{-6}$.

Table 3. Predicted perihelion times for comet 17P/Holmes between the years 1885 and −1004.[a]

Return No.	Perihelion time (ET)	Return No.	Perihelion time (ET)	Return No.	Perihelion time (ET)	Return No.	Perihelion time (ET)	Return No.	Perihelion time (ET)
1	1885 Jul. 19.80	60	1426 Sept. 17.54	119	942 Apr. 28.22	178	400 Jun. 3.96	237	−156 Apr. 11.99
2	1878 Aug. 24.36	61	1418 Sept. 9.75	120	933 Oct. 16.26	179	390 Oct. 31.09	238	−166 Jan. 25.70
3	1871 Oct. 13.48	62	1410 Oct. 24.27	121	925 Mar. 30.69	180	381 Mar. 12.98	239	−177 Oct. 27.36
4	1864 Dec. 3.96	63	1402 Dec. 10.73	122	916 Sept. 18.43	181	371 Aug. 15.85	240	−187 Aug. 27.80
5	1857 Dec. 11.31	64	1395 Mar. 20.84	123	908 Mar. 4.62	182	362 Jan. 18.41	241	−197 Aug. 19.13
6	1850 Nov. 9.13	65	1387 Aug. 12.97	124	899 May 14.38	183	352 Jul. 7.58	242	−208 Dec. 17.37
7	1843 Oct. 11.15	66	1380 Jan. 11.85	125	890 Jul. 6.54	184	342 Dec. 25.91	243	−223 Jun. 15.32
8	1836 Sept. 18.82	67	1372 Jun. 28.00	126	881 Sept. 11.94	185	333 May 23.76	244	−239 May 23.20
9	1829 Aug. 22.74	68	1364 Dec. 11.72	127	873 Jan. 4.55	186	323 Nov. 4.54	245	−255 Mar. 24.36
10	1822 May 6.72	69	1357 May 31.11	128	863 Nov. 9.23	187	314 May 7.07	246	−272 Aug. 23.04
11	1814 Nov. 19.42	70	1349 Nov. 13.33	129	854 Aug. 18.98	188	304 Dec. 4.24	247	−288 Jan. 22.01
12	1807 Jun. 7.43	71	1342 Apr. 19.90	130	845 Jun. 10.87	189	295 Aug. 25.11	248	−305 Nov. 29.03
13	1800 Jan. 10.70	72	1334 Aug. 3.66	131	836 Mar. 11.66	190	286 Apr. 25.18	249	−321 Nov. 16.56
14	1792 Aug. 25.87	73	1326 Oct. 13.96	132	826 Nov. 28.18	191	277 Jan. 14.06	250	−337 Sept. 23.72
15	1785 Apr. 16.30	74	1318 Dec. 21.50	133	817 Aug. 24.04	192	267 Sept. 15.51	251	−352 Dec. 7.32
16	1777 Nov. 29.52	75	1310 Sept. 20.42	134	808 May 10.91	193	258 Apr. 29.03	252	−366 Feb. 26.65
17	1770 Jul. 7.16	76	1302 May 7.39	135	799 Feb. 16.55	194	248 Nov. 20.46	253	−381 May 13.10
18	1762 Oct. 22.43	77	1293 Dec. 7.32	136	790 Jan. 20.86	195	239 May 30.34	254	−396 Jun. 20.56
19	1754 Nov. 29.15	78	1285 Jul. 19.71	137	780 Jun. 18.83	196	230 Jan. 4.36	255	−410 Nov. 10.92
20	1747 Jan. 4.24	79	1277 Mar. 11.05	138	770 Oct. 22.86	197	220 Jun. 25.63	256	−424 Dec. 6.80
21	1738 Aug. 19.40	80	1268 Oct. 24.54	139	761 Feb. 21.54	198	210 Oct. 26.68	257	−437 Mar. 12.52
22	1730 Jan. 23.89	81	1260 Jun. 19.23	140	751 Jul. 18.21	199	201 Feb. 8.21	258	−451 Jul. 4.94
23	1721 Jun. 12.98	82	1252 May 9.49	141	741 Sept. 26.20	200	191 May 2.07	259	−465 Aug. 24.43
24	1712 Nov. 20.17	83	1244 Apr. 13.86	142	731 Nov. 2.41	201	181 Aug. 7.80	260	−479 Oct. 13.57
25	1704 May 16.59	84	1236 Mar. 16.37	143	722 Jan. 19.53	202	171 Dec. 16.06	261	−491 Jan. 15.84
26	1695 Nov. 19.53	85	1227 Nov. 1.07	144	712 Mar. 13.83	203	162 Mar. 2.30	262	−506 Dec. 11.57
27	1687 May 28.05	86	1219 May 7.79	145	702 May 16.51	204	153 Jun. 21.17	263	−519 Feb. 11.12
28	1678 Oct. 30.50	87	1210 Oct. 29.32	146	692 Aug. 11.88	205	144 Sept. 28.29	264	−533 May 30.11
29	1670 Mar. 6.72	88	1202 May 4.67	147	682 Oct. 25.07	206	136 Jan. 26.22	265	−547 Aug. 7.22
30	1661 Jun. 18.12	89	1193 Nov. 27.22	148	672 Oct. 9.83	207	127 Jun. 13.25	266	−561 Jul. 25.89
31	1652 Oct. 14.53	90	1185 Jul. 5.58	149	662 Oct. 15.28	208	118 Nov. 8.00	267	−574 Apr. 12.60
32	1644 Feb. 26.74	91	1177 Feb. 13.44	150	652 Sept. 21.77	209	110 Apr. 5.12	268	−589 Jan. 15.43
33	1636 May 10.00	92	1168 Nov. 22.38	151	642 Sept. 3.93	210	101 Aug. 28.88	269	−604 Feb. 11.01
34	1628 Jul. 24.97	93	1160 Jul. 8.08	152	632 Sept. 13.36	211	92 Dec. 31.33	270	−619 Jan. 14.89
35	1620 Nov. 25.25	94	1152 Feb. 12.32	153	622 Aug. 19.52	212	84 Apr. 15.07	271	−634 Feb. 25.34
36	1613 Jun. 9.12	95	1143 Sept. 22.30	154	612 Aug. 31.43	213	75 Aug. 10.40	272	−650 Nov. 4.56
37	1605 Dec. 28.16	96	1135 May 1.95	155	605 Mar. 24.38	214	66 Jul. 1.64	273	−665 Sept. 11.16
38	1598 Jul. 28.73	97	1126 Dec. 1.81	156	597 Oct. 20.83	215	57 Jan. 18.78	274	−680 May 5.53
39	1591 Feb. 17.11	98	1118 Jul. 10.43	157	590 May 29.11	216	47 Jul. 5.07	275	−694 Mar. 30.91
40	1583 Sept. 7.07	99	1110 Apr. 26.56	158	583 Jan. 3.50	217	37 Dec. 14.37	276	−709 Dec. 24.79
41	1576 Feb. 28.65	100	1102 Feb. 17.08	159	575 Aug. 4.33	218	28 Jun. 24.83	277	−723 Nov. 19.23
42	1568 Aug. 26.99	101	1093 Dec. 10.00	160	568 Feb. 14.89	219	18 Aug. 24.55	278	−737 Sept. 5.95
43	1560 Nov. 10.69	102	1085 Jun. 22.08	161	560 Aug. 21.93	220	8 Oct. 13.33	279	−751 May 12.40
44	1553 May 20.76	103	1076 Nov. 9.19	162	552 Jul. 14.87	221	−2 Oct. 28.28	280	−764 Feb. 20.24
45	1545 Dec. 1.17	104	1068 Mar. 14.11	163	542 Nov. 7.18	222	−12 Oct. 4.60	281	−778 Mar. 27.76
46	1538 Jul. 5.42	105	1059 Jul. 28.57	164	533 Jan. 27.21	223	−22 Sept. 15.44	282	−792 Jul. 19.93
47	1531 Feb. 8.75	106	1051 Feb. 2.61	165	523 Apr. 9.42	224	−32 Oct. 2.45	283	−806 Dec. 19.48
48	1523 Sept. 19.41	107	1042 Dec. 9.86	166	513 Jul. 14.61	225	−42 Nov. 14.10	284	−819 Mar. 31.84
49	1516 Apr. 21.32	108	1034 Oct. 17.30	167	503 Oct. 28.62	226	−52 Oct. 3.40	285	−833 May 1.81
50	1508 Nov. 16.43	109	1026 Aug. 12.20	168	494 Mar. 3.98	227	−61 May 10.41	286	−846 Feb. 7.07
51	1500 Oct. 22.26	110	1018 Mar. 22.23	169	484 Sept. 26.76	228	−71 Nov. 12.69	287	−863 Apr. 12.89
52	1492 Aug. 27.97	111	1009 Oct. 20.60	170	475 Mar. 26.84	229	−80 May 27.60	288	−880 Jul. 2.94
53	1484 Jun. 25.97	112	1001 May 24.16	171	465 Oct. 8.50	230	−89 Jan. 10.32	289	−897 Nov. 16.11
54	1476 Apr. 9.11	113	993 Jan. 1.05	172	456 May 10.37	231	−99 Aug. 20.56	290	−913 May 27.65
55	1468 Jan. 1.32	114	984 Aug. 4.89	173	447 Jan. 1.01	232	−108 Aug. 7.28	291	−930 Oct. 30.09
56	1459 Sept. 7.44	115	976 Mar. 18.28	174	437 Oct. 15.05	233	−117 Jul. 5.69	292	−948 Apr. 12.61
57	1451 May 27.91	116	967 Dec. 16.64	175	428 Jul. 8.79	234	−126 Jun. 25.00	293	−967 Sept. 27.86
58	1443 Mar. 1.59	117	959 Jun. 4.06	176	419 Apr. 24.43	235	−136 May 14.68	294	−985 Apr. 19.39
59	1434 Dec. 5.11	118	950 Nov. 14.08	177	409 Dec. 15.60	236	−146 May 22.42	295	−1004 Sept. 7.11

[a] The dates are in the Gregorian calendar after 1582 Oct. 15, in the Julian calendar before and on that day.

3. Search Ephemeris

A search for pre-1892, historical records of comet 17P/Holmes as a naked-eye object during, or immediately following, a super-massive explosion is a difficult undertaking. In order to increase a chance of success, favorable conditions for detecting potential candidate objects should be carefully examined in terms of (i) timing, (ii) location in the sky and quality of observing conditions, and (iii) appearance and apparent brightness.

The timing is determined by three constraints. The first is based on our experience with the two observed super-massive events, in 1892-1893 and 2007, which shows that the comet was a naked-eye object for a significant fraction of time between 150 and 240 days after perihelion, suggesting that the search for historical records should essentially be focused on this period of time at each of the returns listed in Table 3. A modest extension of this interval in either direction is advisable, as the two observed events may be expected to cover less than the whole range of possibilities.

The second timing constraint is provided by the list of perihelion times in Table 3, from which the critical post-perihelion interval is to be reckoned. Because of the errors steadily propagating in the perihelion times (Sec. 2), a third constraint enters the considerations. Rather than correcting the tabulated perihelion times t_π by including their errors $\epsilon^*_n(t_\pi)$, one can use the t_π values as listed in Table 3 and account for their errors by incorporating them in the critical period for super-massive explosions — that is, by replacing the nominal interval from 150 to 240 days after perihelion with an extended interval from $150 - |\epsilon^*_n(t_\pi)|$ to $240 + |\epsilon^*_n(t_\pi)|$ days after perihelion.

Because of the significant orbital perturbations of comet 17P/Holmes over the long periods of time, a meaningful search scenario requires that a range of orbital solutions be used to provide a basis for predicting locations of potential candidate objects as a function of time. For this purpose, I have selected the sets of orbital elements at four widely separated returns to the sun, which suggest a degree of scatter across the sky that one can expect over the relevant period of time. The selected orbits refer to the comet's perihelion returns 1591, 1219, 722, and −2 (*i.e.*, 3 BC), covering 16 centuries. The predicted sets of elements for these returns are listed in Table 4, which — like Figure 1 — shows major variations, both systematic with time (like in the perihelion distance) and essentially random (like in the inclination). The regression of the nodal line is seen to reach ~ 180° in the course of the 16 centuries.

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Table 4. Selected sets of orbital elements predicted for comet 17P/Holmes at its returns 1591, 1219, 722, and −2 (equinox J2000.0).[a]

Osculation epoch (ET)[b]	1591 Feb. 10.0	1219 May 24.0	722 Feb. 2.0	−2 Oct. 21.0
Time of perihelion passage (ET)[b]	1591 Feb. 17.11	1219 May 7.79	722 Jan. 19.53	−2 Oct. 28.28
Argument of perihelion (deg)	342.42	293.31	235.11	204.90
Longitude of ascending node (deg)	351.27	30.97	125.14	170.73
Orbit inclination (deg)	20.89	11.80	15.42	21.47
Perihelion distance (AU)	2.4826	2.5666	3.1523	4.1373
Orbit eccentricity	0.3477	0.3844	0.3127	0.1092
Orbital period (yr)	7.43	8.51	9.82	10.01

[a] Based on the reference elements computed by N. Mastrodemos and presented in Table 1.

[b] The dates of the osculation epoch and perihelion passage are in the Gregorian calendar for the 1591 return, in the Julian calendar for the earlier returns.

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The appearance and apparent brightness of potential candidate objects are important in complementing the timing and positional information. As Chinese chronicles (followed by Korean and Japanese annals) are the most important sources of historical data, I briefly address the relevant terminology. For more extensive discourse of this subject, the reader is referred to Ho (1962). In the early phase of evolution of a super-massive explosion (up to about 24-48 hours after the onset), comet 17P appears as an essentially star-like and tailless object to the naked eye, so that useful information is provided by historic records that describe discoveries of suspected novae, which were called "guest stars" (*kho-hsing*) by the Chinese (Ho 1962). Of particular interest is a comment by Duerbeck (2009), who cautioned that some guest stars could not be novae because they were reported to move relative to stars. In his updated catalogue of pre-telescopic galactic novae and supernovae, Duerbeck (2009) assigned a class 4 or 5 to such dubious objects, and these are among the most promising candidates in my quest to identify explosions of comet 17P. On the other hand, the likelihood of such detections is generally low because of the short duration of the early phases of evolution of the comet's explosive events.

As the dimensions of the gradually expanding dust halo reach more than ~10 arcminutes, giving the comet a distinctly disk-shaped (rather than star-like) appearance, the comet's perception may better fit a category that Chinese called "sparkling stars" (*po-hsing*), which according to a definition quoted by Ho (1962), send out their rays evenly in all directions. In still later stages of evolution, when the expanding comet begins to loose its near-perfect symmetry (while still remaining a naked-eye object), its appearance could possibly be classified even as a "broom star" (*hui-hsing* or *sao-hsing*), but descriptions in terms of a "tailed star" (*chhang-hsing*) rule unequivocally out any possibility of identity with comet 17P. And when an object's length is reported to be about 1 "foot" or more (1 foot $\simeq 1\overset{\circ}{.}50 \pm 0\overset{\circ}{.}24$ according to Kiang 1972), the identity with 17P is out of the question regardless of the category to which the object has been attributed.

To estimate the likelihood of comet 17P being observable with the naked eye at a given time and location of a potential candidate object, the search ephemeris includes an apparent visual magnitude H calculated from a standard formula

$$H = H_0 + 5\log(r \cdot \Delta), \tag{3}$$

where r and Δ are, respectively, the heliocentric and geocentric distances (in AU), while the intrinsic magnitude H_0 (at $r = \Delta = 1$ AU) is assumed to be equal to the peak intrinsic magnitude, $(H_0)_{\rm peak}$, of the megaburst of comet 17P in 2007, $H_0 = (H_0)_{\rm peak} = -0.5$ mag (Sekanina 2009a). A minor phase effect has been neglected.

Having addressed issues of the timing, location, appearance, and brightness, the task is now to provide an estimate for a realistic upper limit on the propagated error $\epsilon^*_{\rm lim}$ in the perihelion time and thus for a maximum range of the critical period of time (relative to the nominal perihelion time) to be investigated. For the four selected orbits listed in Table 4, the error propagating in the perihelion time is, as given by Eq. (2), equal to ±2.5 days in 1591, ±10 days in 1219, ±26 days in 722, and ±62 days in 3 BC (when $\langle P \rangle = 8.6$ years from Table 2, $N = 221$ from Table 3, and therefore $n = 231$). At earlier times, comet 17P would remain fainter than apparent magnitude 5 even during the most favorable returns and would not be a naked-eye object during less favorable returns. Based on the above assessment of the error propagating in the perihelion time, I adopt for its upper limit

$$\epsilon^*_{\rm lim} = \epsilon^*_{231}(-2) \simeq \pm 60 \;\; \text{days}, \tag{4}$$

so that the proposed search should cover the time from 90 to 300 days after perihelion.

Absorbed in the error $\epsilon^*_n(t_\pi)$ is a small conversion factor between the Universal Time, UT, and the Ephemeris Time, ET. The purpose of ET — now more commonly known as Coordinate Time, CT, and identical, within a very small fraction of a second, with the Terrestrial Time, TT (which itself differs by 32.2 seconds from the atomic time, TAI) — is to remove the effects on UT of variations in the earth's rate of rotation (*i.e.*, in the length of the day), caused primarily by lunar and solar tides. Though minute, these irregularities are systematic and accumulate to a sizable temporal effect over very long periods of time. The correction, $\Delta T = {\rm ET} - {\rm UT}$, which was +29 seconds in 1950 and +64 seconds in 2000, amounted to only several seconds between 1830 and 1900 but reached considerable positive values many centuries ago, over a time scale that is relevant to this work. Morrison and Stephenson (2004, 2005) have investigated this problem and provided an expression to approximate the difference between ET and UT during the past three millennia. With ΔT in hours, their formula yields for a year Y

$$\Delta T = -0.006 + 0.889(\Delta Y)^2, \tag{5}$$

where $\Delta Y = 10^{-3}\,(Y - 1820)$. Thus, the correction ΔT was +0.04 hr in 1591, +0.3 hr in 1219, about +1 hr in 722, and nearly +3 hr in 3 BC; it never exceeded 0.2 percent of the error $\epsilon^*_n(t_\pi)$. In the 7th century BC, the uncertainty in the derived correction ΔT has been estimated by Morrison and Stephenson (2005) at ±500 seconds or ±0.14 hour.

Because the error $\epsilon^*_n(t_\pi)$ is smaller than ±60 days for returns more recent than two millennia ago, the time interval from 90 to 300 days after perihelion, adopted universally in the search ephemeris below, is longer than that based on the two known super-massive explosions, thereby addressing the concern — mentioned near the beginning of this section — that the two observed events may not cover the whole possible range of explosion times. And if the comet's post-explosion fading should proceed very slowly, as in 2007-2008, the end time of the interval may still turn out to be rather conservative.

The search ephemeris for historical records of comet 17P/Holmes is presented in Table 5 with a 20-day step in the date. For each date, the comet's predicted right ascension (α), declination (δ), and apparent magnitude [defined by Eq. (3)] are derived at the four selected returns (1591, 1219, 722, and −2) and at eight post-perihelion times (90, 120, 150, 180, 210, 240, 270, and 300 days), taking in essence the perihelion time as a parameter. These data are listed only when the comet is more than 45° from the sun. For smaller elongations, at which the comet becomes increasingly more difficult to observe, the entries are replaced with dots.

Table 5 provides critical information that constrains and streamlines the search for historical records of comet 17P. It shows in the first place that *no observation made between mid-March and the end of April of any year could refer to this comet*. More detailed inspection shows that around the 13th century, the "forbidden" time zone began even earlier, in mid-February.

Second, in spite of the orbital instability of 17P seen from Figure 1, the area of the sky that the exploding comet passed through during the 16 centuries covered in Table 5 is greatly restricted. The limits of this region range from about $22^{\rm h}10^{\rm m}$ to $5^{\rm h}00^{\rm m}$ in right ascension and from about −21° to +43° in declination (eq. J2000.0). The equatorial coordinates predicted by the ephemeris are strongly correlated in the sense that declination always increases with increasing right ascension, so that the areal extent of the ephemeris positions is actually much smaller than indicated by the overall spans of the coordinates. In the order of increasing right ascension, the exploding comet may have at various returns passed through the following 11 constellations: Aquarius, Pegasus, Pisces, Andromeda, Triangulum, Cetus, Aries, Perseus, Eridanus, Taurus, and Orion.

Third, in the long run the apparent motion of comet 17P has a tendency to regress with time in right ascension and to advance with time in declination, even though neither trend is universally valid. As far as the brightness is concerned, the most favorable season is shown in Table 5 to be September to October throughout the 16 centuries covered, which corresponds typically to the perihelion times in January through June (6 months), depending on the orbital position of the super-massive explosion. Returns with such perihelion times were generally less common before 1892 than between

Table 5. Search ephemeris for comet 17P/Holmes at four selected returns to the Sun (equinox J2000.0).[a]

Date of observation[b] (0^{h}ET)	Return to Sun	Time after perihelion																							
		90 days			120 days			150 days			180 days			210 days			240 days			270 days			300 days		
		α_{2000}	δ_{2000}	H	α_{2000}	δ_{2000}	H	α_{2000}	δ_{2000}	H	α_{2000}	δ_{2000}	H	α_{2000}	δ_{2000}	H	α_{2000}	δ_{2000}	H	α_{2000}	δ_{2000}	H	α_{2000}	δ_{2000}	H
		h m	°		h m	°		h m	°		h m	°		h m	°		h m	°		h m	°		h m	°	
Jan. 1	1591	22 45	−5.3	3.9	23 05	−0.3	3.9	23 25	+4.7	3.9	23 45	+9.8	3.9	0 06	+14.9	4.0	0 27	+19.9	4.0	0 49	+24.6	4.1	1 12	+29.2	4.1
	1219		......			......		23 27	−8.4	4.3	23 48	−5.0	4.3	0 09	−1.6	4.4	0 29	+1.9	4.4	0 49	+5.2	4.5	1 08	+8.5	4.5
	722	0 28	−11.4	4.8	0 48	−10.0	4.8	1 09	−8.5	4.7	1 29	−6.9	4.7	1 50	−5.2	4.7	2 11	−3.4	4.8	2 31	−1.7	4.8	2 51	+0.1	4.8
	−2	1 02	−5.9	5.8	1 16	−5.8	5.8	1 30	−5.6	5.8	1 44	−5.5	5.8	1 58	−5.3	5.7	2 12	−5.1	5.7	2 26	−4.9	5.7	2 42	−4.7	5.7
21	1591		......		23 20	+0.8	4.1	23 39	+5.4	4.1	23 57	+10.0	4.2	0 16	+14.5	4.2	0 35	+18.8	4.2	0 55	+23.0	4.3	1 15	+27.0	4.4
	1219		......			......			......			......		0 21	0.0	4.5	0 39	+3.1	4.6	0 57	+6.1	4.7	1 15	+9.1	4.8
	722		......		0 57	−7.8	4.9	1 16	−6.4	4.9	1 35	−4.8	4.9	1 54	−3.3	4.9	2 13	−1.7	5.0	2 32	−0.1	5.0	2 50	+1.5	5.0
	−2	1 10	−4.3	6.0	1 23	−4.2	5.9	1 36	−4.0	5.9	1 49	−3.8	5.9	2 02	−3.6	5.9	2 15	−3.4	5.9	2 28	−3.2	5.9	2 41	−3.0	5.9
Feb. 10	1591		......			......			......			......		0 31	+15.0	4.4	0 49	+18.9	4.4	1 07	+22.6	4.5	1 26	+26.2	4.6
	1219		......			......			......			......			......			......			......			......	
	722		......			......			......			......		2 04	−1.3	5.1	2 21	+0.2	5.1	2 39	+1.7	5.2	2 56	+3.2	5.2
	−2		......			......			......			......			......		2 23	−1.7	6.0	2 35	−1 5	6.0	2 48	−1.3	6.0
Mar. 2	1591		......			......			......			......			......			......			......		1 41	+26.3	4.7
	1219		......			......			......			......			......			......			......			......	
	722		......			......			......			......			......			......			......			......	
	−2		......			......			......			......			......			......			......			......	
⋮	⋮		⋮			⋮			⋮			⋮			⋮			⋮			⋮			⋮	
May 1	1591		......			......			......			......			......			......			......			......	
	1219	0 37	−3.1	4.1		......			......			......			......			......			......			......	
	722		......			......			......			......			......			......			......			......	
	−2		......			......			......			......			......			......			......			......	
21	1591	0 57	+8.7	4.0		......			......			......			......			......			......			......	
	1219	0 50	−2.4	3.9	1 11	+1.3	4.1	1 30	+4.7	4.2	1 48	+7.8	4.4		......			......			......			......	
	722	2 16	+0.4	4.9		......			......			......			......			......			......			......	
	−2	2 28	+3.2	6.0	2 40	+3.4	6.0		......			......			......			......			......			......	
Jun. 10	1591	1 10	+10.3	3.8	1 29	+14.8	4.0	1 49	+18.8	4.1	2 07	+22.4	4.3		......			......			......			......	
	1219	0 59	−2.4	3.6	1 21	+1.7	3.8	1 42	+5.4	4.0	2 01	+8.7	4.2	2 19	+11.6	4.4	2 37	+14.2	4.6	2 53	+16.6	4.8	3 09	+18.7	4.9
	722	2 28	+0.5	4.7	2 47	+2.1	4.8	3 05	+3.5	4.9	3 23	+4.9	5.0	3 39	+6.3	5.1		......			......			......	
	−2	2 37	+3.3	5.8	2 51	+3.4	5.9	3 04	+3.6	5.9	3 16	+3.8	5.9	3 29	+4.0	6.0	3 42	+4.1	6.0	3 54	+4.3	6.0	4 06	+4.5	6.1
30	1591	1 18	+11.5	3.5	1 39	+16.4	3.7	2 00	+20.6	3.9	2 21	+24.3	4.1	2 41	+27.5	4.3	3 01	+30.2	4.5	3 20	+32.5	4.6		......	
	1219	0 59	−3.7	3.3	1 25	+1.1	3.5	1 48	+5.3	3.8	2 09	+8.9	4.0	2 29	+12.1	4.2	2 47	+15.0	4.4	3 05	+17.4	4.6	3 21	+19.6	4.8
	722	2 37	−0.2	4.5	2 57	+1.5	4.6	3 16	+3.1	4.7	3 34	+4.6	4.9	3 52	+6.1	5.0	4 09	+7.4	5.1	4 25	+8.6	5.2	4 40	+9.8	5.3
	−2	2 43	+2.8	5.7	2 57	+3.0	5.7	3 11	+3.2	5.7	3 25	+3.3	5.8	3 38	+3.5	5.8	3 51	+3.7	5.9	4 04	+3.9	5.9	4 17	+4.0	5.9

Jul. 20	1591	1 17	+11.9	3.2	1 41	+17.4	3.4	2 05	+22.1	3.6	2 28	+26.1	3.9	2 51	+29.4	4.1	3 13	+32.1	4.3	3 34	+34.4	4.5	3 55	+36.2	4.6
	1219	0 47	−6.6	3.0	1 18	−0.9	3.2	1 45	+4.1	3.5	2 09	+8.3	3.7	2 31	+12.0	3.9	2 52	+15.1	4.1	3 11	+17.8	4.4	3 29	+20.1	4.6
	722	2 38	−1.9	4.3	3 01	+0.1	4.4	3 22	+1.9	4.5	3 42	+3.6	4.7	4 00	+5.2	4.8	4 18	+6.7	4.9	4 35	+8.0	5.0	4 51	+9.2	5.1
	−2	2 43	+1.7	5.5	2 59	+1.9	5.5	3 14	+2.1	5.6	3 28	+2.3	5.6	3 43	+2.5	5.7	3 57	+2.7	5.7	4 10	+2.9	5.8	4 24	+3.1	5.8
Aug. 9	1591	1 02	+11.0	2.9	1 32	+17.6	3.1	2 00	+23.1	3.3	2 27	+27.5	3.6	2 53	+31.2	3.8	3 17	+34.1	4.0	3 41	+36.4	4.2	4 05	+38.1	4.4
	1219	0 19	−11.2	2.8	0 56	−4.5	3.0	1 28	+1.5	3.2	1 57	+6.6	3.4	2 23	+10.9	3.6	2 47	+14.6	3.9	3 09	+17.7	4.1	3 29	+20.3	4.3
	722	2 30	−4.7	4.1	2 56	−2.4	4.2	3 20	−0.2	4.3	3 42	+1.8	4.4	4 02	+3.6	4.6	4 22	+5.3	4.7	4 40	+6.8	4.8	4 58	+8.2	5.0
	−2	2 36	−0.2	5.3	2 53	+0.1	5.4	3 10	+0.4	5.4	3 26	+0.6	5.4	3 41	+0.9	5.5	3 56	+1.1	5.5	4 11	+1.4	5.6	4 26	+1.6	5.6
29	1591	0 31	+8.4	2.6	1 06	+16.3	2.8	1 40	+23.0	3.0	2 11	+28.3	3.3	2 42	+32.5	3.5	3 11	+35.8	3.8	3 39	+38.3	4.0	4 06	+40.2	4.2
	1219	23 26	−16.3	2.7	0 19	−9.2	2.8	0 57	−2.6	3.0	1 32	+3.5	3.2	2 02	+8.7	3.4	2 30	+13.1	3.6	2 55	+16.8	3.8	3 19	+19.8	4.1
	722	2 11	−8.5	3.9	2 40	−5.8	4.0	3 07	−3.2	4.1	3 32	−0.9	4.2	3 56	+1.3	4.3	4 17	+3.2	4.5	4 38	+5.0	4.6	4 57	+6.6	4.7
	−2	2 22	−2.5	5.2	2 40	−2.2	5.2	2 58	−1.9	5.2	3 15	−1.6	5.3	3 32	−1.3	5.3	3 49	−1.0	5.4	4 05	−0.6	5.4	4 21	−0.3	5.5
Sept. 18	1591	23 46	+3.8	2.5	0 25	+12.9	2.6	1 03	+20.9	2.8	1 39	+27.5	3.0	2 14	+32.8	3.3	2 49	+36.9	3.5	3 22	+39.9	3.7	3 53	+42.1	4.0
	1219	22 54	−19.8	2.8	23 37	−13.5	2.9	0 17	−7.0	3.0	0 54	−0.7	3.1	1 28	+5.2	3.2	2 00	+10.3	3.4	2 29	+14.7	3.6	2 56	+18.5	3.8
	722	1 41	−12.4	3.8	2 13	−9.6	3.8	2 43	−6.8	3.9	3 11	−4.2	4.0	3 38	−1.7	4.1	4 03	+0.6	4.3	4 26	+2.7	4.4	4 47	+4.6	4.5
	−2	2 01	−5.1	5.1	2 20	−4.7	5.1	2 39	−4.4	5.1	2 57	−4.0	5.2	3 16	−3.7	5.2	3 34	−3.3	5.2	3 51	−3.0	5.3	4 08	−2.6	5.3
Oct. 8	1591	23 04	−1.1	2.6	23 41	+7.9	2.7	0 18	+16.5	2.8	0 55	+24.3	2.9	1 32	+30.8	3.1	2 10	+36.2	3.3	2 47	+40.2	3.5	3 23	+43.2	3.7
	1219	22 25	−21.0	3.1	23 03	−15.9	3.1	23 41	−10.3	3.1	0 17	−4.4	3.2	0 51	+1.4	3.3	1 23	+6.8	3.4	1 54	+11.7	3.6	2 23	+16.0	3.7
	722	1 08	−15.1	3.8	1 40	−12.6	3.8	2 12	−10.0	3.9	2 42	−7.3	3.9	3 10	−4.7	4.0	3 37	−2.2	4.1	4 03	+0.1	4.2	4 27	+2.3	4.4
	−2	1 38	−7.1	5.1	1 57	−6.8	5.1	2 16	−6.5	5.1	2 35	−6.2	5.1	2 54	−5.8	5.2	3 12	−5.5	5.2	3 31	−5.1	5.2	3 49	−4.8	5.2
28	1591	22 37	−4.5	2.9	23 09	+3.3	2.9	23 41	+11.4	2.9	0 14	+19.2	3.0	0 49	+26.4	3.1	1 24	+32.8	3.3	2 01	+38.0	3.4	2 39	+42.2	3.6
	1219	22 12	−20.5	3.5	22 46	−16.3	3.4	23 18	−11.6	3.4	23 50	−6.6	3.4	0 21	−1.4	3.5	0 51	+3.6	3.6	1 21	+8.5	3.7	1 49	+13.0	3.8
	722	0 41	−16.1	4.0	1 11	−14.0	4.0	1 41	−11.8	4.0	2 10	−9.4	4.0	2 39	−6.9	4.1	3 06	−4.4	4.1	3 33	−2.0	4.2	3 59	+0.2	4.3
	−2	1 18	−8.2	5.3	1 36	−8.0	5.2	1 54	−7.8	5.2	2 12	−7.5	5.2	2 31	−7.2	5.2	2 49	−6.9	5.2	3 07	−6.6	5.2	3 26	−6.3	5.2
Nov. 17	1591	22 27	−6.1	3.3	22 54	+0.5	3.2	23 21	+7.5	3.2	23 49	+14.5	3.3	0 18	+21.3	3.3	0 49	+27.8	3.4	1 21	+33.6	3.5	1 55	+38.6	3.6
	1219	22 13	−19.3	3.8	22 42	−15.6	3.7	23 10	−11.5	3.7	23 38	−7.2	3.7	0 05	−2.7	3.8	0 31	+1.7	3.8	0 58	+6.1	3.9	1 23	+10.4	4.0
	722	0 26	−15.5	4.3	0 52	−13.8	4.2	1 19	−11.9	4.2	1 46	−9.8	4.2	2 12	−7.6	4.2	2 38	−5.4	4.3	3 04	−3.2	4.3	3 29	−1.0	4.4
	−2	1 05	−8.3	5.4	1 21	−8.1	5.4	1 38	−7.9	5.4	1 55	−7.7	5.4	2 12	−7.5	5.3	2 29	−7.3	5.3	2 47	−7.1	5.3	3 04	−6.8	5.3
Dec. 7	1591	22 20	−6.3	3.6	22 53	−0.6	3.6	23 17	+5.3	3.6	23 40	+11.4	3.6	0 05	+17.4	3.6	0 30	+23.3	3.6	0 57	+28.8	3.7	1 26	+33.9	3.8
	1219	22 23	−17.5	4.0	22 48	−14.1	4.0	23 13	−10.5	4.0	23 37	−6.7	4.0	0 01	−2.8	4.0	0 24	+1.2	4.1	0 47	+5.1	4.1	1 10	+8.8	4.2
	722	0 22	−14.0	4.5	0 45	−12.4	4.5	1 08	−10.8	4.5	1 32	−8.9	4.5	1 56	−7.0	4.5	2 20	−5.1	4.5	2 43	−3.1	4.5	3 06	−1.1	4.5
	−2	1 00	−7.6	5.6	1 15	−7.4	5.6	1 30	−7.3	5.6	1 45	−7.1	5.5	2 01	−6.9	5.5	2 17	−6.7	5.5	2 33	−6.5	5.5	2 49	−6.3	5.5
27	1591	22 41	−5.6	3.8	23 02	−0.5	3.8	23 22	+4.7	3.8	23 43	+10.0	3.9	0 04	+15.2	3.9	0 26	+20.4	3.9	0 49	+25.3	4.0	1 13	+30.0	4.0
	1219	......			23 01	−12.2	4.2	23 23	−8.9	4.2	23 45	−5.4	4.2	0 06	−1.9	4.3	0 27	+1.6	4.3	0 47	+5.1	4.4	1 07	+8.4	4.5
	722	0 25	−12.0	4.7	0 46	−10.6	4.7	1 08	−9.0	4.7	1 29	−7.3	4.7	1 50	−5.6	4.7	2 11	−3.9	4.7	2 32	−2.1	4.7	2 53	−0.3	4.7
	−2	1 01	−6.3	5.8	1 15	−6.2	5.8	1 29	−6.0	5.7	1 43	−5.8	5.7	1 57	−5.7	5.7	2 12	−5.5	5.7	2 26	−5.3	5.7	2 41	−5.1	5.7

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[a] The peak intrinsic magnitude of super-massive explosions is assumed to be equal to that of the 2007 megaburst, $(H_0)_{\rm peak} = -0.5$ mag.

[b] The dates are in the Gregorian calendar for the 1591 return, in the Julian calendar for the earlier returns.

[text continued from page 9]

1892 and 2007. Statistically, the probability is of course 6/12 = 0.50, but in the 15th to 18th centuries, for example, the probability was only 0.43 (cf. Table 3), compared to 0.65 in 1892-2007 and 0.78 in 1950-2007 (cf. Table 1 of Paper 1). The high probabilities for recent returns were due to the comet's mean orbital period of almost exactly 7 years between 1972 and 2007.

And fourth, the perihelion distance, which has been steadily decreasing with time, is the reason for the comet's gradually increasing brightness (all else being equal) over the centuries, an effect that is strikingly apparent from Table 5. Indeed, except at times of favorable observing conditions, the comet's brightness some two millennia ago would barely exceed the naked-eye detection threshold of apparent magnitude 6 during a super-massive explosion comparable in power to the megaburst of 2007. This provides a major argument for discontinuing the search for historical records at earlier times.

4. Sources of Historical Records Employed in the Search

Original sources of historical records of comets can be divided into two broad categories by the geographical location of their origin: (i) Far-Eastern or Oriental, and (ii) European and Middle-Eastern. The first category consists of Chinese, Korean, Japanese, and Ryukyu sources (in the chronological order in which they began), the second category covers Babylonian, Greek, Roman, Arabian, Byzantine, and other regional sources, as well as more recent sources from individual European countries. There also are sources that do not fit either category (*e.g.*, from India), but these make up only a very small fraction of the total. As a rule, the oriental, especially Chinese, sources contain more accurate information and are generally considered more reliable than other sources.

Numerous compilations of historical records of both categories are available that summarize information from a great variety of original sources (old chronicles and annals) and are accessible in English. In this work I use the following compilations that update and correct the results of similar earlier efforts:

(i) Ho's (1962) catalogue of ancient and medieval observations of comets and novae from oriental sources, with 581 objects reported to have been observed between the 14th century BC and December 1600. This catalogue includes revised data from Tamura's (1958) work on Korean historical records of comets and from Williams' (1871) catalogue of ancient and medieval comets.

(ii) Hasegawa's (1980) catalogue of ancient and naked-eye comets, with more than 1000 entries between 2316 BC and AD 1700 from all recorded sources, and with additional 63 entries from the 18th century. This catalogue includes corrections to Pingré's (1783, 1784) and Baldet's (1949) classical works and also remarks on Ho's (1962) catalogue. Additions and corrections to Hasegawa's catalogue appear in Jansen (1991).

(iii) Chambers' (1889) catalogue of 539 comets between ~ 1770 BC and AD 1889 with unknown orbits and a supplementary catalogue (Chambers 1909) with additional 25 comets between ~ 1140 BC and 1905. The comet designations before Christ are systematically off by 1 year (*e.g.*, the bright comet in 5 BC, or in the year −4, is listed as occurring in 4 BC).

(iv) Kronk's (1999, 2003) cometographic volumes 1 (ancient-1799) and 2 (1800-1899), each of which provides two groups of potential candidates: comets with unknown orbits and uncertain objects. Although it is unlikely that another super-massive explosion of comet 17P occurred in the course of the 19th century, inspection of Kronk's second volume furnishes information that supports this premise.

(v) Duerbeck's (2009) list of 91 pre-telescopic galactic novae and supernovae, from the 14th century BC to AD 1604, which offers a convenient update to previous summaries of historical records of these objects, especially that by Stephenson (1976). As mentioned in Sec. 3, of interest as potential detections of comet 17P in an early phase of explosion development are the objects that Duerbeck (following Stephenson) classifies as dubious novae or supernovae, in part because of indications of their motion among stars.

(vi) Hsi's (1958) new catalogue of 90 ancient novae between ~ 1400 BC and AD 1690, which is a thorough remake of Lundmark's (1921) list of 60 suspected novae between 134 BC and AD 1828. The value of these publications is in their longer temporal coverage, compared to Duerbeck's (2009) list, by incorporating more recent naked-eye (though no longer pre-telescopic) objects. Lundmark has also included meridian observations. Unlike Duerbeck and Lundmark, Hsi has assigned no grade to the events to indicate their likelihood of being novae, but he has admitted that some comets may still contaminate his catalogue.

5. Search for Pre-1892 Observations of Comet 17P/Holmes

With all necessary prerequisites completed, I now proceed with the search itself. The strategy is straightforward — identify all candidate objects from the six source compilations in Sec. 4 for which none of the following applies:

(1•) The object has already been identified (*e.g.*, as a nova, Halley's comet, etc.).

(2•) Only very crude information is available on the date of observation (with an uncertainty greater than ±1 month).

(3•) The date of observation is not between 90 and 300 days after perihelion of one of the returns listed in Table 3.

(4•) The date of observation is at the wrong time of the year, comet 17P being then too close to the sun in the sky for detection (cf. Table 5).

(5•) No diagnostic information is reported on the object's location in the sky.

(6•) The object's location is outside the region of the sky predicted for comet 17P.

(7•) The object's description (*e.g.*, the presence of a prominent tail) implies an appearance that is inconsistent with that of comet 17P during or shortly after a super-massive explosion.

Because of sensitive aspects of the application of test (6•), the search has been conducted in two stages. The ephemeris from Table 5 has been employed in the first stage to identify select candidate objects that passed tests (1•) to (5•) and (7•) and whose reported location did not manifestly meet a requirement for immediate rejection based on test (6•). There were two categories of such select candidate objects: (a) those whose reported position was in one of the eleven constellations (or in one of the equivalent asterisms employed in the Chinese and other Far-Eastern sources) implied by the ephemeris (cf. Sec. 3); and (b) those for which the location was specified by only a general direction in the sky (north, northeast, *etc.*). All such select candidate objects advanced to the second stage of the search, where the status of each has been determined by more rigorous positional scrutiny, involving comparison of the reported location on the reported date (or in the course of the reported interval of time) with the predicted equatorial coordinates based on the adopted reference orbit.

In practical application of the first stage of the search, the top priority has been test (1•), followed by (2•). For an object that fails to pass either one of them, all other tests become irrelevant. Test (3•) has been applied next, because it turns out that, as a filter, it is by far the most restrictive. Tests (4•) through (7•) have been applied only to objects that have passed the first three tests; relatively few additional objects have been rejected as a result. For example, when employed to examine Ho's (1962) catalogue, test (1•) has eliminated $19\frac{1}{2}$ percent of all entries, which included novae and supernovae deemed probably real by Duerbeck (2009), 24 returns of comet 1P/Halley (cf. Yeomans and Kiang 1981; also, Marsden and Williams 2008), two returns of comet 109P/Swift-Tuttle (Marsden *et al.* 1993, Yau *et al.* 1994), one return of comet 55P/Tempel-Tuttle (cf. Hind 1872, Kanda 1933, Schubart 1966), and comets with known parabolic orbits between 147 BC and AD 1596 [derived by various authors, primarily by Hasegawa (1979), and compiled by Marsden and Williams 2008]. Test (2•) has eliminated additional 7 percent of entries from Ho's catalogue, while test (3•) has led to rejection of additional 68 percent of the total (or fully 93 percent of the remaining entries). Subsequent application of tests (4•) through (7•) has eliminated only 4 percent of the total. Only nine entries of Ho's (1962) catalogue, or $1\frac{1}{2}$ percent of the total, have passed all seven tests of the first stage of the search for 17P to become select objects.

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Table 6. Potential historical observations of comet 17P/Holmes during or shortly after a super-massive explosion. (Objects passing the first stage of search; a star in front of the date marks objects also passing the second stage.)

Date(s) of observation[a]	Return No.[b]	Days after perihelion	Location in sky[c]	Reported category[d]	Source(s)[e]	Reference(s)[f]
1661 Dec. 16–20	30	181–185	Aqu	guest	Kor	Ha(985)
*1621 May 22	35	178	E	red star	Chi	Ha(968), Hs(87), Kr
1419 Jun. 12	61	276	NE	object	Jap	Ha(805), Ho(496), Kr
*1269 Aug.	80	296 ± 15	E	comet	Sco	Ha(702), Ch(405), Kr
1220 Jan. 25	86	263	Peg	broom	Jap, Eur	Ha(671), Ho(422), Cs(13), Kr
1110 Dec. 24	99	242	E	comet	Eur	Ha(622)
1035 Jan. 15	108	90	Cet	star	Chi	Ha(574), Ho(369), Du, Kr
*836 Jul. 31 ±15	131	142 ± 15	E	spark	Kor	Ha(454), Ho(290), Kr
742 Jun.	141	262 ± 15	N	comet	Con	Ha(422)
400 Sept. 19 ±14	178	108 ± 14	E	spark	Kor	Ha(276), Ho(184), Kr
*305 Sept. 19 ±15	188	289 ± 15	Tau	spark	Chi	Ha(248), Ho(164), Hs(22), Ch(157), Kr
153 Nov. 18 ±15	204	150 ± 15	E, NE	broom	Kor	Ha(179), Ho(102), Kr
−136 Oct. 5 ±15	235	144 ± 15	NE	comet	Chi	Ha(88), Ho(37), Ch(44), Kr
−146 Oct. 26 ±15	236	157 ± 15	NW	comet	Chi	Ha(81), Ho(33), Ch(41), Kr

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[a] First two dates are in the Gregorian calendar, the rest in the Julian calendar. For the second stage of search, see the text of Sec. 5.

[b] As defined in Table 3.

[c] Either abbreviation of a constellation (equivalent, for Far-Eastern sources, to an asterism that was referred to); or a general direction in the sky (N = north, NE = northeast, etc.).

[d] Abbreviated terms used in most Far-Eastern sources (cf. Sec. 3): guest = guest star (*kho-hsing*); spark = sparkling star (*po-hsing*); broom = broom star (*hui-hsing* or *sao-hsing*); or terms that describe broader categories, such as star, comet, or object.

[e] Oriental sources: Chi = China, Jap = Japan, Kor = Korea; other sources: Eur = Europe, Sco = Scotland, Con = Constantinople.

[f] Author of catalogue followed, where applicable, by object's catalogue number in parentheses: Du = Duerbeck (2009); Ha = Hasegawa (1980); Ho = Ho (1962); Ch = Chambers (1889); Cs = Chambers (1909); Hs = Hsi (1958); Kr = Kronk (1999).

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The described methodology of the first stage of search examination has been applied to the catalogues of historical records on transient celestial events (Sec. 4) and it has resulted in identifying a total of 14 select objects that could potentially be pre-1892 observations of comet 17P/Holmes during or shortly after a super-massive explosion. These objects are listed in Table 6 and are further tested in the second stage of the search in the following. One notes the somewhat-unexpected absence of events from the 18th century. Because all positional information in the historical sources is referred to the equinox of the date, it is this equinox — rather than the standard equinox of J2000 — that is used in the following accounts of the candidate objects.

1661 December 16-20. This object from a Korean source, listed only by Hasegawa (1980), is an attractive candidate for comet 17P/Holmes in the early phase of a super-massive explosion because it not only occurred at the right time in the generally correct area of the sky, but also because it was described as a *guest star* (*i.e.*, star-like and tailless) that changed its apparent position in 4 days. Amazingly, the year of its appearance is 231 years prior to the 1892-1893 event, almost exactly twice the time span between the 1892-1893 and 2007 explosions. Unfortunately, however, closer inspection shows some disconcerting discrepancies. As quoted by Hasegawa (1980), this was an evening object in Aquarius: on December 16 it was at 5° of the 10th lunar mansion,[1] implying $\alpha_{1661} = 20^{\rm h}49^{\rm m}$, and 102° from the pole, or $\delta_{1661} = -12^\circ$. Four days later it moved to 1° of the 11th lunar mansion, implying $\alpha_{1661} = 21^{\rm h}18^{\rm m}$, and 97° from the pole, or $\delta_{1661} = -7^\circ$. The ephemeris predicts comet 17P to have been in Pegasus, near the border with Pisces: at $\alpha_{1661} = 23^{\rm h}16^{\rm m}$ and $\delta_{1661} = +7^\circ\!.4$ on the first date and at $\alpha_{1661} = 23^{\rm h}19^{\rm m}$ and $\delta_{1661} = +7^\circ\!.7$ on the second date. An estimated error of ±1.7 days in the perihelion time would cause changes of only $\pm\ 1^{\rm m}$ in right ascension and $\pm\ 0^\circ\!.2$ in declination. If having the same peak intrinsic brightness as in 2007, the comet is predicted to have been of apparent magnitude 4.8. The discrepancies of some 30°-35° in right ascension and 15°-20° in declination are one order of magnitude larger than errors with which positions of comets were determined in the 17th century [see, *e.g.*, the positions of comet 1668 recorded by P. G. Candone on a star chart and read by Kreutz (1901) more than 200 years later]. Thus, the object of 1661, which also moved much too fast, was obviously not comet 17P.

1621 May 22. This object would *à priori* have been a highly unlikely candidate for comet 17P, if the 1661 object — only 40 years later — had been positively identified. The late May date suggests a relatively small elongation from the sun, while the eastern location indicates a morning object. According to Williams (1871) this was a comet, but both Lundmark (1921) and Hsi (1958) listed it as a possible nova, although Lundmark considered it a very dubious one. It is in this sense that Hasegawa's (1980) term "uncertain object" is to be understood. Both Williams and Lundmark erroneously gave the Julian-calendar date of May 12. The search ephemeris places comet 17P $\sim$ 35° from the sun, at $\alpha_{1621} = 1^{\rm h}29^{\rm m}$, $\delta_{1621} = +18^\circ\!.2$, about $1^\circ\!.3$ to the southwest of β Ari. With a close double star γ Ari, about $1^\circ\!.5$ to the south of β Ari, the comet and the two stars should have made up an eye-catching, tight, nearly equilateral triangle, which around 4 a.m. local time would have been fairly low above the eastern horizon. If observed shortly after a super-massive explosion comparable to the 2007 megaburst in terms of peak intrinsic brightness, comet 17P would have been of apparent magnitude 4.4, which compares with 2.6 for β Ari and 3.5 for a combined magnitude of γ^1 and γ^2 Ari (magnitudes 3.9 and 4.8, respectively). The reported reddish color may be an effect of the spectral contrast with the two stars (A5 for β Ari and A1 for γ^1 Ari) strengthened by a low altitude (the comet rose about 3 a.m., the sunrise was about 5 a.m. local time, with the moon still below the horizon). With only the soft positional constraint available, the circumstances for the 1621 object are consistent with those expected for comet 17P, even though the sighting must have occurred under less-than-ideal observing conditions.

1419 June 12. This object is difficult to interpret and it barely made this select list. The historical record is peculiar in two ways. One is the manner in which the event is described, as "an object like a (*chhang-hsing*) comet" (tailed star) — avoiding a more explicit wording that would result in the object's immediate rejection on the strength of test (7•). Because of the oblique way of conveying the object's appearance, I decided (with qualms) to retain this object on the select list. This could in fact be a bright fireball, but here the second peculiar detail comes into play: the object was observed from 23:00 to 1:00. Trains of even very prominent fireballs do not persist for two hours. Fortunately, the search ephemeris provides a straightforward solution, since the predicted position of comet 17P, $\alpha_{1419} = 2^{\rm h}26^{\rm m}$ and $\delta_{1419} = +21^\circ\!.4$, in the constellation Aries, shows that it would not have risen above the horizon until about 2 a.m. local time and it would then be located in the east rather than the northeast. Thus, the 1419 object was positively not comet 17P.

1269 August. This poorly constrained event is generally consistent with the predicted positional information on comet 17P from the search ephemeris. The only contentious point is the breadth of the observing period. While Hasegawa (1980) gives August, both Chambers (1889) and Kronk (1999) adopt August-September. Since August 1 was already 281 days after nominal perihelion, the end of September corresponds to 341 days after nominal perihelion. Following the 2007 megaburst, the last naked-eye observation of 17P was made 311 days after perihelion (cf. Paper 1) under superior conditions compared to those in 1269. The predicted equatorial coordinates for the August-September time slot are $\alpha_{1269} = 2^{\rm h}12^{\rm m}$ to $1^{\rm h}56^{\rm m}$ and $\delta_{1269} = +17^\circ\!.3$ to $+20^\circ\!.7$. The comet was in the constellation Aries, between 90° and 160° from the sun, and in the east in the early part of the night (10-11 p.m. local time). With the peak intrinsic brightness of the 2007 megaburst, the apparent magnitude is predicted to have been 4.0-4.2 in the two-month period, but this estimate does not include the fading that necessarily sets in sooner or later after the early phase of the super-massive explosion has terminated. The identity of this 1269 object with comet 17P is therefore possible, but given the insufficient details in the historic record, little convincing evidence can be offered.

1220 January 25. The first of apparently three independent comets that appeared in early 1220. There is a discrepancy between the location given by Hasegawa (1980), which is Pegasus, and Ho (1962), who refers to an asterism corresponding to an area in the northwestern portion of Andromeda, southwestern Cassiopeia, and northern Lacerta, containing among others the stars ι, κ, λ, and 7 And and α, β, 5, and 11 Lac. The search ephemeris places comet 17P at $\alpha_{1220} = 0^{\rm h}15^{\rm m}$ and $\delta_{1220} = +1^\circ\!.4$, in the constellation Pisces. The general area referred to by Ho (1962) and Kronk (1999) is some 40°-50° from the ephemeris position. This large discrepancy is also consistent with a difference in the direction of the object in the sky, to the northwest, while the ephemeris suggests the west-southwest. Hasegawa's (1980) claim that the comet of 1220 was also observed in Europe (specifically in England) is questionable, because Chambers (1909), to whom Hasegawa refers, mentions a "stupendous" comet in 1219, not 1220. Comet 17P is not involved in any case, which is not inconsistent with the "broom-star" (*hui-hsing*) appearance of the object reported by the Japanese.

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[1] For more information on the lunar mansions in the Chinese uranography, see e.g. Kiang (1972).

1110 December 24. This object is listed only by Hasegawa (1980), who suspects that this may be a nova. Yet, it is included in none of the catalogues of novae — Duerbeck's (2009), Stephenson's (1976), Hsi's (1958), or Lundmark's (1921). The search ephemeris places comet 17P in the constellation Pisces, at $\alpha_{1110} = 0^{\rm h}35^{\rm m}$ and $\delta_{1110} = -0^{\circ}\!\!.3$, while the eastern sky was dominated by the constellations Gemini, Canis Minor, and Monoceros in the evening after sunset, by Virgo, Coma Berenices, and Leo around local midnight, and by Ophiuchus and Hercules in the morning before sunrise. The comet would have been in the southwestern sky in the evening and could not be identical with this 1110 object.

1035 January 15. Although Hasegawa (1980) places this object in the constellation Cetus, the position equivalent to the Chinese asterism *Wai-Phing* is in Pisces according to Ho (1962). Delimited by the stars α, δ, ϵ, ζ, μ, ν, and ξ Psc, this asterism occupies the intervals from $23^{\rm h}59^{\rm m}$ to $1^{\rm h}13^{\rm m}$ in right ascension and from $-2^{\circ}\!\!.1$ to $+2^{\circ}\!\!.6$ in declination (eq. 1035.0). Described in the Chinese annals as a star with "vaporous rays", this object is classified by both Stephenson (1976) and Duerbeck (2009) in the lowest category of novae, with a significant contamination by comets. Neither Lundmark (1921) nor Hsu (1958) list this object as a nova in their catalogues. The search ephemeris shows that comet 17P should have been in the constellation Aquarius, at $\alpha_{1035} = 22^{\rm h}33^{\rm m}$ and $\delta_{1035} = -18^{\circ}\!\!.7$, only 33° from the sun and more than 25° to the southwest from the nearest point of the reported area of the sky. The propagated error in the perihelion time is estimated at ±15 days, and if the perihelion occurred by this much earlier than predicted by the nominal orbit in Table 3, the comet's position would approach the observed position by about $13^{\rm m}\!\!.3$ in right ascension and by $1^{\circ}\!\!.3$ in declination and would not materially improve the situation. The error in the perihelion time of more than 100 days would be required to bring the discrepancy down to less than 5°. Such a large error in the perihelion time is unrealistic, and it appears certain that the 1035 object was not comet 17P.

836 July 31 ± 15 days. The poorly constrained location of this candidate object can be only crudely examined. The search ephemeris places comet 17P at $\alpha_{836} = 1^{\rm h}50^{\rm m}$ and $\delta_{836} = -6^{\circ}\!\!.1$ on July 17 and at $\alpha_{836} = 2^{\rm h}05^{\rm m}$ and $\delta_{836} = -7^{\circ}\!\!.2$ on August 15. Near the border of the constellations Cetus and Eridanus in mid-July, the comet then moved into Eridanus and remained more than 90° from the sun. A few hours after local midnight, it was gradually gaining elevation in the east-southeastern sky. In mid-August, it would be observable earlier and essentially in the southeast. Its apparent brightness, if observed soon after the onset of a super-massive explosion, would probably be near magnitude 4. Given the soft constraints, it is possible to argue for this object's identity with comet 17P, the second half of July being preferable to the first half of August. In July, the comet would have been only several degrees from o Cet (Mira), but the confusion with this pulsating star is unlikely, as Mira (together with Algol, δ Cep, and possibly other prominent variables in this part of the sky) was apparently known to ancient astronomers both in the Orient (*e.g.*, Gaspani 1998) and in Greece (*e.g.*, Wilk 1996).

742 June. Like the account of the 1110 object, this information, conveyed by Hasegawa (1980), comes from Pingré's (1783, 1784) catalogue. The predicted positions of comet 17P are in the constellation Taurus, at $\alpha_{742} = 2^{\rm h}44^{\rm m}$ and $\delta_{742} = +3^{\circ}\!\!.2$ at the very beginning of June and at $\alpha_{742} = 3^{\rm h}18^{\rm m}$ and $\delta_{742} = +5^{\circ}\!\!.2$ at the end. Only objects at declinations exceeding +50° could have appeared above the northern horizon at Constantinople. The comet should have shown up in the early morning sky in the east, and it could not be identical with the reported object.

400 September 19 ± 14 days. In this case the predicted positions of comet 17P are in the constellation Cetus, at $\alpha_{400} = 0^{\rm h}27^{\rm m}$ and $\delta_{400} = -19^{\circ}\!\!.5$ on September 5 and at $\alpha_{400} = 0^{\rm h}12^{\rm m}$ and $\delta_{400} = -22^{\circ}\!\!.6$ on October 3. These positions are inconsistent with the reported sighting in the east in the sense that in early September the comet was above the southeastern horizon, and in early October closer to the south than the east. In addition, at an estimated magnitude 4.5 or fainter, the comet would have been a difficult object to spot at its southern declination. When higher above the horizon before sunrise, the comet would be further to the south. It appears that the inaccurate description notwithstanding, the likelihood of the object being comet 17P is practically nil.

305 September 19 ± 15 days. In spite of the uncertainty in the observing time, this object is very intriguing. Three Chinese annals recorded (see Ho 1962) that during the period of time between September 5 and October 4, a sparkling star (*po-hsing*) appeared at the 18th lunar mansion and the 19th lunar mansion, with no mention of a tail. The text does not say explicitly whether the object was observed repeatedly, nor is it clear whether the order in which the two lunar mansions are listed implies the direction of motion. Since each lunar mansion covers a whole sector of the sky in the direction of increasing right ascension from the mansion's determinative star to the determinative star of the next mansion, no information is provided on the declination (or the polar distance).[2] If the object moved slowly and/or was observed just once or during a very short period of time, the right ascension of its location(s), based on the description in the historical records, was likely to be relatively near (within a few degrees of) the determinative star of the 19th mansion. The 18th lunar mansion is the Pleiades and its determinative star is 17 Tau ($\alpha_{305} = 2^{\rm h}08^{\rm m}$, $\delta_{305} = +17^{\circ}\!\!.3$), while the 19th lunar mansion is delimited by its determinative star ϵ Tau ($\alpha_{305} = 2^{\rm h}53^{\rm m}$, $\delta_{305} = +13^{\circ}\!\!.8$) and by α Tau. I adopt $\alpha_{305} = 2^{\rm h}50^{\rm m} \pm 20^{\rm m}$ as a working hypothesis for the object. As Kronk (1999) has noticed, the object would have been visible most of the night, under excellent conditions except for about a week or so around September 23, when the moon would have interfered. With the nominal perihelion time t_π = 304 December 4 (Table 3), the search ephemeris predicts for comet 17P $\alpha_{305} = 3^{\rm h}22^{\rm m}$ and $\delta_{305} = -7^{\circ}\!\!.1$ for September 5, $\alpha_{305} = 3^{\rm h}23^{\rm m}$ (maximum) and $\delta_{305} = -7^{\circ}\!\!.9$ for September 13, and $\alpha_{305} = 3^{\rm h}20^{\rm m}$ and $\delta_{305} = -10^{\circ}\!\!.1$ for October 4. This places the comet outside the object's right-ascension box by some 3° on the average. However, the propagated error in the perihelion time is estimated from Eq. (2) at ±46 days. Since the nominal time of appearance of this object is rather late, 289 ± 15 days after perihelion (Table 6), a preferred correction to the comet's passage through perihelion is positive, up to t_π + 46 days. If the comet reached perihelion at this time, on January 19, 305, the time of appearance would be reduced to more plausible 243 ± 15

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[2] For a complete list of determinative stars in the Chinese uranography, see Kiang (1972).

days after perihelion. The search ephemeris then predicts for comet 17P $\alpha_{305} = 2^{\rm h}51^{\rm m}$ and $\delta_{305} = -9^{\circ}\!.7$ for September 5 and $\alpha_{305} = 2^{\rm h}46^{\rm m}$ and $\delta_{305} = -13^{\circ}\!.0$ for October 4. The comet's predicted right ascension is now in nearly perfect agreement with that of the object. It would remain within the error box even if the error in the perihelion time were only some +14 to +18 days (rather than +46 days), depending on the date of appearance. The comet's predicted position is actually in the constellation or Eridanus, fairly near the Taurus southern border. The region contains no prominent stars, the three brightest (ν, μ, and o^1 Eri) being near magnitude 4.0. If of a peak intrinsic brightness comparable to that of the 2007 megaburst, the comet might have apparent magnitude 4.5 to 4.8, depending on the date of appearance and the perihelion date, and would therefore be bright enough to attract observers' attention. I thus arrive at a conclusion that, the greater perihelion distance of $\sim$ 3.5 AU notwithstanding, the chances of comet 17P being identical with this object look rather promising.

153 November 18 ± 15 days. Reported by a single Korean source, this object was described as a "broom star" (*hui-hsing*), which during the month from November 4 to December 3 was seen first in the east and then in the northeast. The search ephemeris predicts comet 17P to move during this period of time through the constellation Cetus from $\alpha_{153} = 23^{\rm h}50^{\rm m}$ and $\delta_{153} = -23^{\circ}\!.5$ on November 4 to $\alpha_{153} = 23^{\rm h}55^{\rm m}$ and $\delta_{153} = -21^{\circ}\!.7$ on December 3. In the evening, the comet would be above the south-southeastern horizon in early November and above the southern horizon in early December. Thus, both its location in the sky and the direction of its motion during the month are inconsistent with those of the object, ruling out the identity. Shifting the perihelion time by as much as 50-60 days has no effect on this conclusion.

−136 October 5 ± 15 days. The positions of comet 17P predicted by the search ephemeris are $\alpha_{-136} = 23^{\rm h}34^{\rm m}$ and $\delta_{-136} = -12^{\circ}\!.3$ on September 21 and $\alpha_{-136} = 23^{\rm h}22^{\rm m}$ and $\delta_{-136} = -14^{\circ}\!.7$ on October 20. The comet was in the constellation Cetus. Because of the negative declination, the comet could not be observed, regardless of its brightness, above the northeastern horizon and could not be identical with the object. This conclusion is insensitive to the choice of perihelion time within limits predicted by Eq. (2).

−146 October 26 ± 15 days. This return of comet 17P is similar to that of −136. The comet's predicted coordinates are $\alpha_{-146} = 23^{\rm h}49^{\rm m}$ and $\delta_{-146} = -13^{\circ}\!.9$ on October 12 and $\alpha_{-146} = 23^{\rm h}40^{\rm m}$ and $\delta_{-146} = -15^{\circ}\!.2$ on November 10. The comet was again in the constellation Cetus, and because of the negative declination, it could not be detected above the northwestern horizon. The identity is again ruled out.

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Table 7. Sets of osculating orbital elements predicted for comet 17P/Holmes at its returns 1620, 1268, 836, and 304 (equinox J2000.0).[a]

Osculation epoch (ET)[b]	1620 Nov. 24.0	1268 Oct. 13.0	836 Mar. 15.0	304 Dec. 13.0
Time of perihelion passage (ET)[b]	1620 Nov. 25.25	1268 Oct. 24.54	836 Mar. 11.66	304 Dec. 4.24
Argument of perihelion (deg)	342.42	306.75	237.56	215.84
Longitude of ascending node (deg)	351.02	14.78	113.97	154.43
Orbit inclination (deg)	20.89	14.44	14.93	21.24
Perihelion distance (AU)	2.4956	2.6249	2.9565	3.4662
Orbit eccentricity	0.3452	0.3637	0.3350	0.2130
Orbital period (yr)	7.44	8.38	9.37	9.24

[a] Based on the reference elements presented in Table 1.

[b] The dates of the osculation epoch and perihelion passage are in the Gregorian calendar for the 1620 return, in the Julian calendar for the earlier returns.

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In summary, application of the two-stage search to historical records of transient objects suggests a pre-1892 detection of four possible super-massive explosions of comet 17P/Holmes. They are marked with the asterisks that precede the dates in Table 6 and extend as far back in time as the early 4th century. The reported locations in the sky of three of these candidate objects — dated 1621 May 22, August 1269, and July-August 836 — are not very well constrained, yet the identity of these objects with comet 17P cannot be ruled out. The fourth object, dated September 305, looks quite promising, the comet's large perihelion distance of $\sim$ 3.5 AU notwithstanding. The sets of osculating orbital elements of comet 17P for these four returns — with the nominal perihelion times in November 1620, October 1268, March 836, and December 304 — are presented in Table 7. Two potentially diagnostic properties of this sequence of events are: (i) the observations of all four objects were made between late May and the beginning of October, even though the search ephemeris in Table 5 shows that favorable conditions extend through the months October-January as well; and (ii) the dates make a chronological succession with the gaps between them steadily decreasing with time: 531 years between the earliest two, 433 years between the next two, 352 years between the last two, and 271-272 years between the last one and the 1892/93 event; in terms of the number of intervening revolutions about the sun, the gaps are 57 cycles between AD 304 and 836, 51 between 836 and 1268, 45 between 1268 and 1620, and 35 between 1620 and 1892. These numbers contrast with the 16 revolutions elapsed between 1892 and 2007. Allowing for missed events, the pre-1892 intervals must be regarded as upper limits to the recurrence time of super-massive explosions of comet 17P. The question to be addressed next is the dependence of the recurrence time on the perihelion distance and orbital dimensions in general from the standpoint of heat transport in the comet's nucleus.

6. Dependence of the Recurrence Time on Dimensions of the Orbit

An in-depth investigation of heat transfer into the interior of the nucleus of comet 17P/Holmes was conducted in Paper 2 for the average orbital dimensions between 1892 and 2007, characterized by a perihelion distance of 2.235 AU. The product of the modeling of heat transport was an effective thermal-conductivity coefficient $K_{\rm eff}$ of terrain layers that measures a heat-penetration rate needed to reach the point of runaway crystallization of gas-laden amorphous water ice in a reservoir located beneath each layer. Approximating the mean recurrence time of layer jettisoning (and of super-massive explosions), ν_0, a function of each layer's thickness and a critical temperature at its base (taken as 50 meters and 106°.3 K, respectively, in Paper 2), by the interval between the 1892-1893 event and the 2007 megaburst ($\nu_0 = 16$ revolutions or 115 years), I found in Paper 2 that consistent solutions to the equation of heat transfer required for $K_{\rm eff}$ a nominal value between 0.26 and 0.30 W $\rm m^{-1}$ $\rm K^{-1}$, depending weakly on the variations, during the revolution about the sun, in the solar-radiation energy incident on the the comet's surface at a chosen point.

Because the comet's perihelion distance has systematically been decreasing with time over the past millenia (Figure 1) and was nearly 3.5 AU at the time of the first suspected detection of a super-massive explosion 17 centuries ago (Sec. 5), it is expected that the recurrence time in the past was longer than the 16 revolutions, because the amount of solar-radiation energy received by the comet per revolution varies as $q^{-\frac{1}{2}}$ with the perihelion distance, q. To determine how much longer and to gain an insight into the problem of variations with the perihelion distance, I have first introduced a dimensionless ratio x of the perihelion distance to the aphelion distance Q:

$$x = \frac{q}{Q} < 1, \tag{6}$$

which allows the eccentricity e and the osculating orbital period P to be expressed as

$$e = \frac{1-x}{1+x}, \tag{7a}$$

$$P = X(1+x)^{\frac{3}{2}}, \tag{7b}$$

where $X = 0.3536 Q^{\frac{3}{2}}$, Q is in AU, and P in tropical years. Next, I keep the aphelion distance constant at $Q = 5.5$ AU, an average that is suggested by the sets of orbital elements in Table 7. Then $X = 4.56$ years and the perihelion distance q is the only orbital element on which the heat-transfer solution depends.

The heat-transfer calculations have followed closely the methodology developed and extensively described in Sec. 9.1 of Paper 2, to which the reader is referred for details. Several perihelion distances have been selected, and for each an eccentricity has been calculated satisfying equation (7a). The equations of heat transfer have been integrated using $K_{\rm eff} = 0.3$ W $\rm m^{-1}$ $\rm K^{-1}$ in an isothermal approximation, which in Paper 2 was called a *standard scenario*, characterized for all points of the surface by the ratio of the cross-sectional area to the total surface area of a spherical nucleus. The prime result of the computer runs is a mean recurrence time for jettisoning layers *stacked on top of each other*, a quantity that can also be called a mean exposure lifespan $\mathcal{L}_{\rm layer}$ of layers exposed on the surface of comet 17P. For the given orbital dimensions and the chosen physical parameters governing the process of layer removal, $\mathcal{L}_{\rm layer}$ is a constant that is related to the recurrence time ν_0 by

$$\mathcal{L}_{\rm layer} = \frac{\pi D^2}{A_{\rm layer}} \nu_0, \tag{8}$$

where $D = 3.3$ km is the diameter of the nucleus of comet 17P (Lamy *et al.* 2000; Snodgrass *et al.* 2006) and $A_{\rm layer} \simeq 5$ $\rm km^2$ is the base area of an average terrain layer (Belton *et al.* 2007). The mean recurrence time ν_0 of 16 revolutions (or 115 years) at $q = 2.235$ AU is equivalent to the mean exposure lifespan $\mathcal{L}_{\rm layer}$ of 110 revolutions (or ~ 790 years).

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Table 8. Mean exposure lifespan of 50-meter thick layer on surface of comet 17P/Holmes as function of perihelion distance (at constant aphelion distance of 5.5 AU).

Perihelion distance q (AU)	Orbital eccentricity e	Orbital period P (yr)	Mean exposure lifespan	
			rev.	yr
2.0	0.4667	7.26	95	690
2.5	0.3750	8.00	128	1024
3.0	0.2941	8.76	166	1454
3.5	0.2222	9.55	211	2014
4.0	0.1579	10.35	264	2733
4.5	0.1000	11.18	328	3667

The results of the heat-tranport calculations are summarized in Table 8. The mean exposure lifespan (in revolutions) can be fitted empirically to mean relative accuracy of about ±3 percent by

$$\mathcal{L}_{\rm layer} = 32.1 q^{1.52}, \tag{9}$$

with the residuals leaving a slight systematic trend. A better fit, to mean relative accuracy of ±0.5 percent, is achieved by

$$\mathcal{L}_{\rm layer} = 49 q^{0.7} \exp\left[1.97(\log q)^2\right]. \tag{10}$$

Expressed as a function of the orbital period (in years), the exposure lifespan is

$$\mathcal{L}_{\rm layer} = 0.335 P^{20/7}, \tag{11}$$

to mean relative accuracy of ±1 percent. Because $\mathcal{L}_{\rm layer}$ varies rather strongly with q (or P) on time scales much shorter than is its value, predicted values of $\mathcal{L}_{\rm layer}$ as a function of time should strictly be computed by appropriately integrating one of the above expressions. However, estimates can readily be provided by approximately interpolating the tabulated values, especially because only crude averages are needed. The mean exposure lifespan between the beginning of the 4th century and the end of the 19th century is estimated at about 1300 years, so that the mean recurrence time, ν_0, which is, from Eq. (8), about 15 percent of the exposure lifespan $\mathcal{L}_{\rm layer}$, is just about 200 years. One could thus expect, statistically, that between the beginning of the 4th century and the end of the 19th century there would be some 8 super-massive explosions. If the findings of Sec. 5 are interpreted to indicate that the identity of 17P with the AD 305 object is probable to between 50 and 100 percent and with the other three objects to between 10 and 100 percent each, the overall detection probability of the conducted search is between 10 and 50 percent. Given the major odds against detection, this result appears by no means to be disappointingly low.

7. Comet 17P Not a Candidate for the Star of Bethlehem

The prediction of a perihelion passage of comet 17P in the year −2, or 3 BC, may instinctively invoke a thought that this return could provide a candidate for the Star of Bethlehem. This short section is meant to discourage any such intention, as this identity is effectively ruled out by two robust arguments: (i) there is no historical record of any transient object from around the critical period of time; and (ii) comet 17P should have had a perihelion distance of more than 4 AU at this return and it could hardly be brighter than apparent magnitude 6 in the aftermath of a super-massive explosion (cf. Table 5), becoming a celestial phenomenon that could not possibly attract the wise men's attention. As for the true identity of the Star of Bethlehem, one can either accept the hypothesis arguing that the comet — or, less probably, nova — in 5 BC was a plausible candidate,[3] consistent with a general consensus on the time of the birth of Christ (*e.g.*, Humphreys 1991), or relegate the story to the realm of myth (*e.g.*, Jenkins 2004).

8. The Future of Comet 17P/Holmes and Its Investigations

The reference orbit from Table 1 has next been integrated forward in time to ascertain the future motion of comet 17P until the early 22nd century. As seen from Table 9, the comet's orbit is predicted to remain fairly stable during this period of time, with only moderate perturbations due to an approach to Jupiter in April 2051. Relative to the respective average between 2014 and 2114, the perihelion distance will vary within ±0.10 AU, the orbital period within ±0.22 year, and the inclination within about $\pm 0\overset{\circ}{.}55$.

Comparison of these predicted sets of elements with Kinoshita's (2009) independently derived orbits shows an exceptionally good agreement. The differences in the perihelion time range from less than 2 minutes in 2014 to less than 25 minutes in 2106, the last entry on Kinoshita's list. The other elements likewise agree extremely closely: the angles to better than $5''$, the perihelion distance to within 1000 km, and the eccentricity to better than 2×10^{-6}. However, it should be kept in mind that the megaburst in 2007 may have introduced an unpredictable nongravitational perturbation of the comet's orbital motion, which could result in changes in the comet's future perihelion times that cannot be estimated and incorporated in current orbital integrations.

Because the recurrence time of super-massive explosions of comet 17P is by no means constant (Sec. 2), it is not possible to predict the time of the next event. However, from available evidence one would not expect it before the end of this century (Paper 1). During the period of time covered by the predicted orbital sets in Table 9, the primary long-term objective is to monitor the comet's activity — temporal variations in its dust and gas production throughout the orbit.

As I already observed in Sec. 8.1 of Paper 1, there is evidence from the light curve over the years 1899-2009 that it takes a long time for comet 17P to "recuperate" from a super-massive explosion and to gradually "settle down" to its normal, quiescent state. This long-term, secondary phase of the comet's post-explosion evolution, observed after the 1892-1893 explosive event and again following the 2007 megaburst, is not to be confused with the primary post-explosion phase, manifested by a more or less rapidly subsiding light curve within several weeks to a few months after the event's onset. The secondary phase begins after the termination of this primary phase and may extend over two revolutions about the sun after the super-massive explosion, as pointed out in greater detail below.

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[3] Although the Chinese historical source calls this object a broom star (*hui-hsing*; Ho 1962), Duerbeck (2009) — using the classification by Stephenson (1976) and despite that author's expressed doubts — regards it a possible nova or — because of the reported duration of more than 70 days — even a supernova. Hsi (1958) suggests that this may have been a radio point source, while Lundmark (1921) does not include this object in his catalogue of suspected novae. Both Pingré (1743) and Williams (1871) describe it as a comet.

Table 9. Predicted osculating orbital elements for comet 17P/Holmes at next 15 returns to the sun (eq. J2000.0).[a]

Epoch (ET)	2014 Apr. 13.0	2021 Mar. 7.0	2028 Jan. 30.0
Epoch JD	2456760.5	2459280.5	2461800.5
T (ET)	2014 Mar. 27.4738	2021 Feb. 19.7200	2028 Jan. 31.4694
ω (deg)	24.5135	24.4675	24.5076
Ω (deg)	326.7649	326.6204	326.5937
i (deg)	19.0916	19.0319	19.0034
q (AU)	2.056575	2.080676	2.091960
e	0.431860	0.427757	0.426093
P (yr)	6.89	6.93	6.96
Epoch (ET)	2034 Dec. 24.0	2041 Dec. 27.0	2048 Nov. 20.0
Epoch JD	2464320.5	2466880.5	2469400.5
T (ET)	2035 Jan. 10.6382	2041 Dec. 9.0864	2048 Nov. 5.2544
ω (deg)	24.4460	24.3815	24.5609
Ω (deg)	326.5924	326.4679	326.3944
i (deg)	19.0205	19.0254	19.0319
q (AU)	2.082353	2.064433	2.059149
e	0.427698	0.430680	0.431387
P (yr)	6.94	6.91	6.89
Epoch (ET)	2056 Jan. 3.0	2063 Mar. 27.0	2070 Jun. 18.0
Epoch JD	2472000.5	2474640.5	2477280.5
T (ET)	2056 Jan. 8.3780	2063 Apr. 3.4474	2070 Jun. 25.3446
ω (deg)	28.6202	28.7324	28.6662
Ω (deg)	324.8115	324.7526	324.7555
i (deg)	18.2047	18.1766	18.1884
q (AU)	2.206773	2.219302	2.208001
e	0.408898	0.407225	0.409404
P (yr)	7.21	7.24	7.23
Epoch (ET)	2077 Sept. 9.0	2084 Dec. 1.0	2092 Feb. 23.0
Epoch JD	2479920.5	2482560.5	2485200.5
T (ET)	2077 Sept. 3.3078	2084 Nov. 14.8211	2092 Feb. 17.7506
ω (deg)	28.4669	28.6877	29.3974
Ω (deg)	324.6396	324.5575	324.0757
i (deg)	18.1961	18.1988	18.0188
q (AU)	2.192518	2.187975	2.250282
e	0.411575	0.412169	0.402188
P (yr)	7.19	7.18	7.30
Epoch (ET)	2099 Jun. 26.0	2106 Oct. 28.0	2114 Jan. 19.0
Epoch JD	2487880.5	2490560.5	2493200.5
T (ET)	2099 Jun. 14.0892	2106 Oct. 8.6929	2114 Jan. 3.0399
ω (deg)	29.4689	29.4819	29.8260
Ω (deg)	324.0392	324.0167	323.4001
i (deg)	17.9933	18.0108	18.0198
q (AU)	2.261066	2.248957	2.181703
e	0.401007	0.402769	0.413907
P (yr)	7.33	7.31	7.18

[a] Based on the reference elements presented in Table 1.

The nature of the secondary post-explosion phase of elevated activity of comet 17P, which remains to be determined, is a major goal of the monitoring campaign proposed for 2010-2015 (Sekanina 2010). There are three basic scenarios that the comet may follow in this activity phase: (i) essentially continuous, or (ii) intermittent, or (iii) temporally restricted. These scenarios are diagnostic of the source and evolution of the ejecta that account for the elevated brightness in the extended post-explosion period of time. The continuously enhanced brightness could be an indication of large amounts of very slowly moving, sizable debris that lingers in the comet's atmosphere ever since the time of the super-massive explosion. Intermittent periods of brightening could be diagnostic of erratic, on-and-off surges of activity from isolated, unstable regions of the nucleus in an excited state. Finally, the elevated brightness that is restricted to only one or a few periods of time could be interpreted as an effect of steadily subsiding erosion of the affected regions of the nucleus, whose areal extent has been gradually (but possibly at variable rates) diminishing with time in the aftermath of the super-massive explosion.

In order for the light curve to be a meaningful measure of variations in the comet's activity, personal and instrumental magnitude corrections (sometimes also referred to as "aperture" corrections; see, *e.g.*, Marcus 1983) need to be applied to the magnitude determinations reported by individual observers to convert these brightness data to a standardized, common photometric system. This procedure is especially necessary when magnitude observations made with the naked eye or binolculars are to be linked with those made with the help of large-aperture telescopes. The issues of personal/instrumental corrections and the integration of corrected magnitudes into a resulting common light curve are addressed in detail in the Appendix.

As is apparent from the presented light curve, the available limited evidence for elevated activity of comet 17P/Holmes in the secondary phase of the post-explosion evolution consists of the following: (i) a moderate outburst, about 4 magnitudes in amplitude, which commenced on about 1899 July 4 or ~ 67 days after perihelion (Sekanina 2009a), as documented by the visual observations made by Perrine (1899, 1900) with the 91-cm refractor of the Lick Observatory and by Barnard (1932) with the 102-cm refractor of the Yerkes Observatory between 43 and 111 days after perihelion; (ii) the 1899/1900 gradually subsiding light curve between 135 and 268 days after perihelion, also based on Perrine's and Barnard's data, and indicating that the comet was in this period of time steadily brighter by nearly 4 magnitudes relative to the quiescent-phase light curve in 1986-2000 (Paper 1); (iii) the 1906 light curve, based on four photographic magnitudes between 167 and 268 days after perihelion obtained by M. Wolf and A. Kopff in Heidelberg (*e.g.*, Wolf 1906; see Paper 1 for the complete list of references) and closely following the 1899/1900 light curve; (iv) the "total" magnitude determinations from CCD imaging observations made by the Catalina Sky Survey group and elsewhere in late 2008 and early 2009, between 523 and 657 days after perihelion, and likewise showing the comet to be nearly 4 magnitudes brighter than in 1986-2000; and (v) a minor outburst, superimposed on this elevated light curve and reported by Miles (2009) to have occurred on 2009 January 4.7 ± 0.5 UT, 439 days after the onset of the megaburst and 611 days after perihelion, which had an amplitude of ~0.6 magnitude measured by the brightness of the inner coma and which may have been a continuation of three marginally detectable quasi-periodic brightenings during the primary phase of the post-explosion evolution, 40 to 140 days after the onset of the megaburst (Kidger 2008, Miles 2009).

With the personal/instrumental corrections applied, the apparent magnitudes $H(\Delta, r)$ have been reduced to a geocentric distance $\Delta = 1$ AU by an inverse-square power law, Δ^{-2}, to determine the *normalized* visual magnitudes H_Δ,

$$H_\Delta(r) = H(r, \Delta) - 5 \log \Delta, \tag{12}$$

neglecting a minor phase effect. The normalized magnitudes from the sets (ii), (iii), and (iv) are plotted against an inverse heliocentric distance $1/r$ in Figure 2, apparently satisfying an empirical law:

$$H_\Delta(r) = [20.4(\pm 0.2)] - [22.6(\pm 0.8)]\,(1/r), \tag{13}$$

where $1/r$ is in AU^{-1}. It should be remembered that this law is during the secondary phase of the post-explosion evolution supported by observations, at best, only in the time interval 135 to 657 days after perihelion, corresponding to a range of heliocentric distances between 2.3 and 4.3 AU.

The nucleus of comet 17P is known to be about 3.3 km in diameter (Lamy *et al.* 2000; Snodgrass *et al.* 2006), as photometrically derived on the assumptions of a geometric albedo of 4 percent and a phase slope of 0.035 mag/deg. The apparent visual magnitude of the nucleus, $h(r, \Delta)$, is then equal to:

$$h(r, \Delta) = 16.6 + 5 \log(r\Delta) + 0.035\beta, \tag{14}$$

where r and Δ are again in AU and β, in degrees, is the phase angle (angle earth-comet-sun). The difference,

$$H(r, \Delta) - h(r, \Delta) = 3.8 - 22.6(1/r) - 5 \log r - 0.035\beta, \tag{15}$$

is always negative and measures the degree of activity on the assumption of validity of Eq. (13). For example, $H - h = -8.5$ magnitudes at 135 days after perihelion (in 1899), −6.8 mag at 268 days after perihelion (in 1906), −5.5 mag 524 days after perihelion (in 2008), and −4.8 mag at 657 days after perihelion (in 2009). Compared with my conclusion that — in the secondary phase of the post-explosion evolution — the comet is nearly 4 magnitudes brighter than in the quiescent phase along much of the receding leg of the orbit, the above results show that in the quiescent phase the nucleus contributes almost one half of the comet's total light at a heliocentric distance of ~ 4.3 AU outbound.

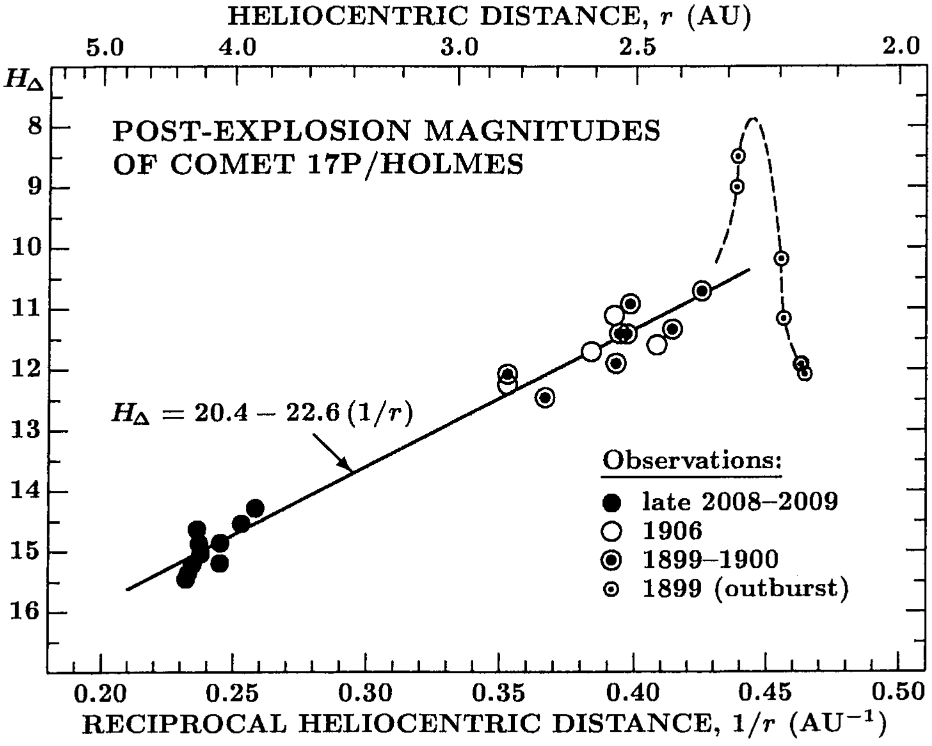

Figure 2. Normalized magnitude H_Δ (at 1 AU from the earth) from the periods of time following the super-massive explosions of comet 17P/Holmes plotted as a function of heliocentric distance. Linked are the post-perihelion brightness estimates from 1899-1900 and 1906 with the post-megaburst light curve from 2008 and 2009. The dashed curve connects the magnitudes shortly before and during the moderate outburst of 1899.

◇ ◇ ◇

[text continued from page 20]

Because of the shortcomings in our knowledge of the light curve of comet 17P (in the quiescent and post-explosion phases alike, especially along the pre-perihelion branch of the orbit), the apparent magnitude $H(r, \Delta)$ based on H_Δ from Eq. (13) does not offer a genuine parametric function of activity but only its proxy that has limited practical application. How much limited? Magnitudes H and h are likely to provide the upper and lower limits on the comet's apparent brightness during much of the investigated period of time and they allow one to judge the nature of activity variations during the secondary phase of the comet's post-explosion evolution (continuous, intermittent, or restricted regime) measured against a certain, however-imperfect standard.

In view of this opportunity, comet observers are encouraged to participate in the proposed monitoring program in 2010-2015. In order to assist such efforts, an ephemeris based on the reference orbit of comet 17P, extending over the six years — and accompanied by the magnitudes H and h — is presented in Table 10. With a 10-day step, the ephemeris covers the whole six-year interval except for times when the comet is at elongations of less than 45° from the sun. Columns 4 and 5, headed "Variation", provide the corrections that apply, respectively, to the right ascension and declination in columns 2 and 3 if the date of perihelion passage is one day later than predicted in Table 9. However, it is unlikely that this prediction is in error by more than a fraction of 1 hour. The total visual magnitude, H, computed from Eq. (12) after inserting for H_Δ from Eq. (13), and the visual magnitude of the nucleus, h, derived from Eq. (14), are listed, respectively, in columns 10 and 11. Both H and h can be converted to the Cousins R magnitudes using an average color index involving the Johnson V magnitude, $V\text{-}R = +0.41 \pm 0.07$, measured for the comet's nucleus by Snodgrass *et al.* (2006). A similar color results from Snodgrass *et al.*'s (2008) plot for the comet's expanding halo shortly after the megaburst of 2007. Adopting from Paper 1 that the visual magnitude of comet 17P is, on the average, 0.12 mag fainter than V, the R magnitudes corresponding to H and h in Table 10 are 0.53 mag brighter.

Table 10 shows that during 2010-2015, $H\text{-}h$ is predicted to vary between −4.2 mag in late February 2010, more than 6 months before aphelion, and −9.1 mag, after the 2014 perihelion. The comet's corrected total magnitude is expected to be (i) between h and H and closer to the former when the comet is in or near its quiescent phase; (ii) either between h and H or close to the latter in the phase of elevated activity; and (iii) brighter than H at times of strongly elevated activity, especially during outbursts.

Sufficiently powerful telescopes should detect the comet, except near its conjunctions with the sun, throughout the orbit, so there is no obstacle to monitoring the comet for light variations during the times listed in Table 10. Since the total brightness of 17P in the aphelion region and along the pre-perihelion branch of the orbit is unknown, any

Table 10. Ephemeris of comet 17P/Holmes for 2010-2015 (equinox J2000.0).

Date (0^hET)	α_{2000}	δ_{2000}	Variation		Δ	r	Phase	Elong.	H	h
	h m	° ′	m	′			°	°		
2010 Jan. 4	10 51.4	+4 51	−0.22	+2.9	4.418	4.996	9.7	121.0	19.1	23.7
14	10 48.5	+4 48	−0.23	+3.0	4.300	5.010	8.4	131.8	19.1	23.6
24	10 44.2	+4 52	−0.23	+3.1	4.201	5.022	6.8	143.0	19.0	23.5
Feb. 3	10 38.9	+5 04	−0.24	+3.1	4.128	5.035	4.9	154.3	19.0	23.4
13	10 32.8	+5 20	−0.25	+3.2	4.084	5.047	2.8	165.7	19.0	23.3
23	10 26.2	+5 41	−0.25	+3.2	4.071	5.058	0.9	175.6	19.0	23.2
Mar. 5	10 19.6	+6 02	−0.25	+3.2	4.091	5.069	2.0	169.6	19.0	23.3
15	10 13.5	+6 24	−0.25	+3.1	4.142	5.079	4.1	158.4	19.0	23.4
25	10 08.1	+6 43	−0.25	+3.0	4.222	5.089	6.1	147.2	19.1	23.5
Apr. 4	10 03.7	+6 58	−0.24	+3.0	4.329	5.099	7.8	136.3	19.1	23.6
14	10 00.6	+7 08	−0.23	+2.9	4.456	5.108	9.2	125.8	19.2	23.7
24	9 58.8	+7 12	−0.23	+2.8	4.601	5.116	10.2	115.6	19.3	23.8
May 4	9 58.3	+7 10	−0.22	+2.7	4.757	5.124	10.9	105.8	19.4	23.9
14	9 59.1	+7 02	−0.21	+2.6	4.920	5.132	11.3	96.4	19.5	24.0
24	10 01.1	+6 48	−0.20	+2.5	5.085	5.139	11.4	87.4	19.5	24.1
Jun. 3	10 04.1	+6 28	−0.19	+2.4	5.249	5.146	11.1	78.6	19.6	24.2
13	10 08.0	+6 03	−0.19	+2.3	5.407	5.152	10.7	70.2	19.7	24.2
23	10 12.8	+5 33	−0.18	+2.3	5.557	5.158	10.0	61.9	19.7	24.3
Jul. 3	10 18.2	+4 58	−0.18	+2.2	5.696	5.163	9.2	53.9	19.8	24.3
13	10 24.1	+4 19	−0.17	+2.2	5.820	5.167	8.2	46.1	19.9	24.3
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Nov. 10	11 47.5	−6 42	−0.17	+2.2	5.798	5.187	8.2	48.0	19.9	24.3
20	11 52.9	−7 39	−0.18	+2.2	5.667	5.185	9.1	56.3	19.8	24.3
30	11 57.5	−8 34	−0.18	+2.2	5.524	5.183	9.9	64.9	19.8	24.3
Dec. 10	12 01.3	−9 25	−0.19	+2.3	5.369	5.181	10.5	73.8	19.7	24.2
20	12 04.2	−10 13	−0.20	+2.4	5.207	5.178	10.9	82.9	19.6	24.2
30	12 06.0	−10 56	−0.20	+2.4	5.042	5.175	11.0	92.2	19.5	24.1
2011 Jan. 9	12 06.6	−11 33	−0.21	+2.5	4.878	5.171	10.7	101.9	19.5	24.0
19	12 05.9	−12 03	−0.22	+2.6	4.720	5.166	10.2	111.8	19.4	23.9
29	12 03.9	−12 26	−0.23	+2.7	4.572	5.162	9.3	122.0	19.3	23.8
Feb. 8	12 00.6	−12 39	−0.24	+2.8	4.440	5.156	8.1	132.4	19.3	23.7
18	11 56.1	−12 43	−0.24	+2.9	4.328	5.150	6.7	142.8	19.2	23.6
28	11 50.6	−12 37	−0.25	+3.0	4.242	5.144	5.0	153.1	19.1	23.5
Mar. 10	11 44.5	−12 22	−0.25	+3.0	4.184	5.138	3.4	162.1	19.1	23.4
20	11 38.1	−11 59	−0.25	+3.1	4.156	5.130	2.5	166.8	19.1	23.4
30	11 31.8	−11 30	−0.24	+3.1	4.159	5.123	3.3	163.0	19.1	23.4
Apr. 9	11 25.9	−10 57	−0.24	+3.1	4.193	5.115	4.9	154.4	19.1	23.5
19	11 21.0	−10 24	−0.23	+3.0	4.255	5.106	6.6	144.5	19.1	23.5
29	11 17.1	−9 53	−0.22	+3.0	4.342	5.097	8.1	134.3	19.2	23.6
May 9	11 14.5	−9 26	−0.22	+2.9	4.449	5.087	9.4	124.4	19.2	23.7

Table 10. (Continued.)

Date (0^hET)	α_{2000}	δ_{2000}	Variation		Δ	r	Phase	Elong.	H	h
	h m	° ′	m	′			°	°		
2011 May 19	11 13.1	−9 05	−0.21	+2.8	4.572	5.077	10.4	114.6	19.2	23.8
29	11 13.1	−8 51	−0.20	+2.7	4.706	5.067	11.1	105.2	19.3	23.9
Jun. 8	11 14.3	−8 44	−0.20	+2.6	4.846	5.056	11.5	96.1	19.4	24.0
18	11 16.6	−8 44	−0.19	+2.5	4.989	5.044	11.6	87.3	19.4	24.0
28	11 20.0	−8 53	−0.19	+2.5	5.130	5.032	11.4	78.8	19.5	24.1
Jul. 8	11 24.3	−9 09	−0.18	+2.4	5.266	5.020	11.0	70.6	19.5	24.1
18	11 29.5	−9 32	−0.18	+2.3	5.393	5.007	10.4	62.6	19.5	24.2
28	11 35.3	−10 01	−0.18	+2.3	5.510	4.993	9.6	54.8	19.6	24.2
Aug. 7	11 41.7	−10 36	−0.18	+2.2	5.613	4.979	8.6	47.2	19.6	24.2
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Dec. 5	13 16.4	−22 22	−0.25	+2.2	5.382	4.774	8.8	47.6	19.3	24.0
15	13 23.2	−23 30	−0.26	+2.2	5.241	4.753	9.8	55.5	19.2	24.0
25	13 29.3	−24 38	−0.28	+2.2	5.086	4.733	10.7	63.7	19.2	23.9
2012 Jan. 4	13 34.6	−25 43	−0.29	+2.3	4.920	4.711	11.5	72.1	19.1	23.9
14	13 38.9	−26 47	−0.31	+2.4	4.748	4.689	11.9	80.6	19.0	23.8
24	13 41.9	−27 48	−0.33	+2.5	4.572	4.667	12.2	89.4	18.9	23.7
Feb. 3	13 43.6	−28 44	−0.35	+2.6	4.396	4.644	12.1	98.5	18.7	23.6
13	13 43.8	−29 35	−0.37	+2.7	4.224	4.621	11.7	107.7	18.6	23.5
23	13 42.4	−30 19	−0.39	+2.8	4.061	4.597	11.0	117.1	18.5	23.4
Mar. 4	13 39.3	−30 54	−0.40	+3.0	3.911	4.573	10.0	126.6	18.4	23.2
14	13 34.6	−31 18	−0.41	+3.2	3.779	4.548	8.7	136.1	18.3	23.1
24	13 28.4	−31 29	−0.42	+3.3	3.669	4.522	7.3	145.1	18.2	23.0
Apr. 3	13 21.3	−31 26	−0.42	+3.5	3.584	4.497	5.8	152.9	18.1	22.9
13	13 13.5	−31 09	−0.42	+3.7	3.526	4.470	4.9	157.7	18.1	22.8
23	13 05.7	−30 39	−0.41	+3.8	3.498	4.443	5.0	157.5	18.0	22.8
May 3	12 58.5	−29 59	−0.40	+3.9	3.498	4.416	6.1	152.4	18.0	22.8
13	12 52.4	−29 12	−0.38	+3.9	3.525	4.388	7.7	144.7	18.0	22.8
23	12 47.7	−28 23	−0.36	+3.8	3.576	4.360	9.3	135.8	18.0	22.9
Jun. 2	12 44.6	−27 35	−0.34	+3.7	3.648	4.331	10.8	126.7	18.0	23.0
12	12 43.2	−26 52	−0.33	+3.6	3.737	4.302	12.1	117.5	18.0	23.1
22	12 43.5	−26 17	−0.32	+3.4	3.838	4.272	13.0	108.6	18.0	23.2
Jul. 2	12 45.5	−25 50	−0.31	+3.3	3.946	4.241	13.7	99.9	18.1	23.2
12	12 48.9	−25 33	−0.30	+3.1	4.059	4.210	14.0	91.5	18.1	23.3
22	12 53.8	−25 26	−0.30	+3.0	4.172	4.179	14.0	83.4	18.1	23.3
Aug. 1	12 59.8	−25 28	−0.30	+2.8	4.282	4.147	13.7	75.6	18.1	23.4
11	13 07.0	−25 40	−0.30	+2.7	4.386	4.115	13.2	68.0	18.1	23.4
21	13 15.2	−25 59	−0.31	+2.6	4.482	4.082	12.5	60.6	18.1	23.4
31	13 24.2	−26 26	−0.31	+2.5	4.568	4.048	11.6	53.5	18.1	23.4
Sept. 10	13 34.1	−27 00	−0.32	+2.4	4.640	4.015	10.5	46.5	18.1	23.4
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

Table 10. (Continued.)

Date (0^hET)	α_{2000}	δ_{2000}	Variation		Δ	r	Phase	Elong.	H	h
	h m	° ′	m	′			°	°		
2013 Jan. 18	16 27.1	−38 17	−0.64	+0.6	4.101	3.532	12.1	48.9	17.1	22.9
28	16 41.4	−39 08	−0.69	+0.3	3.952	3.491	13.5	55.6	16.9	22.8
Feb. 7	16 55.3	−39 58	−0.74	0.0	3.793	3.451	14.7	62.5	16.7	22.7
17	17 08.6	−40 47	−0.79	−0.3	3.627	3.410	15.8	69.6	16.6	22.6
27	17 21.1	−41 37	−0.85	−0.6	3.455	3.369	16.6	76.8	16.4	22.5
Mar. 9	17 32.6	−42 26	−0.92	−1.0	3.279	3.327	17.3	84.1	16.2	22.4
19	17 42.8	−43 17	−0.99	−1.3	3.103	3.285	17.6	91.6	16.0	22.3
29	17 51.5	−44 09	−1.08	−1.7	2.929	3.243	17.7	99.3	15.8	22.1
Apr. 8	17 58.1	−45 03	−1.17	−2.0	2.759	3.200	17.4	107.2	15.5	22.0
18	18 02.4	−45 58	−1.28	−2.2	2.596	3.158	16.7	115.2	15.3	21.8
28	18 04.0	−46 53	−1.39	−2.4	2.445	3.115	15.6	123.5	15.1	21.6
May 8	18 02.5	−47 45	−1.51	−2.4	2.306	3.072	14.2	131.7	14.9	21.4
18	17 57.8	−48 30	−1.62	−2.2	2.185	3.029	12.5	139.8	14.6	21.2
28	17 49.9	−49 02	−1.72	−1.7	2.084	2.985	10.6	147.0	14.4	21.0
Jun. 7	17 39.4	−49 14	−1.79	−1.1	2.005	2.942	9.2	152.4	14.2	20.8
17	17 27.5	−49 02	−1.81	−0.3	1.950	2.899	8.8	154.2	14.1	20.7
27	17 15.5	−48 23	−1.77	+0.4	1.920	2.856	9.8	151.6	13.9	20.7
Jul. 7	17 05.0	−47 20	−1.70	+0.9	1.914	2.812	11.8	145.6	13.8	20.7
17	16 57.1	−45 59	−1.61	+1.1	1.931	2.769	14.3	137.9	13.7	20.8
27	16 52.6	−44 27	−1.50	+1.0	1.966	2.727	16.7	129.5	13.6	20.9
Aug. 6	16 51.7	−42 51	−1.40	+0.7	2.018	2.684	18.9	120.9	13.5	21.0
16	16 54.3	−41 16	−1.32	+0.2	2.082	2.642	20.7	112.6	13.4	21.1
26	17 00.0	−39 47	−1.24	−0.3	2.156	2.601	22.1	104.6	13.4	21.1
Sept. 5	17 08.6	−38 22	−1.18	−1.0	2.235	2.560	23.0	96.9	13.3	21.2
15	17 19.7	−37 03	−1.13	−1.6	2.317	2.520	23.5	89.6	13.3	21.3
25	17 32.8	−35 48	−1.09	−2.3	2.401	2.480	23.6	82.6	13.2	21.3
Oct. 5	17 47.8	−34 34	−1.06	−3.0	2.483	2.442	23.4	76.0	13.1	21.4
15	18 04.2	−33 21	−1.03	−3.7	2.563	2.404	22.9	69.6	13.0	21.4
25	18 21.9	−32 05	−1.01	−4.3	2.638	2.368	22.1	63.5	13.0	21.4
Nov. 4	18 40.6	−30 45	−0.99	−5.0	2.709	2.333	21.0	57.6	12.9	21.4
14	19 00.1	−29 19	−0.97	−5.6	2.774	2.299	19.8	51.9	12.8	21.3
24	19 20.2	−27 46	−0.95	−6.3	2.833	2.267	18.4	46.3	12.7	21.3
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
2014 Jun. 22	2 28.8	+28 10	−1.05	−6.9	2.713	2.165	20.3	47.7	12.1	21.2
Jul. 2	2 48.9	+30 34	−1.08	−6.1	2.660	2.189	21.5	52.2	12.2	21.2
12	3 08.7	+32 50	−1.12	−5.2	2.603	2.217	22.6	56.8	12.3	21.2
22	3 28.1	+34 57	−1.16	−4.3	2.542	2.246	23.5	61.7	12.4	21.2
Aug. 1	3 47.0	+36 56	−1.20	−3.4	2.477	2.276	24.2	66.8	12.4	21.2
11	4 05.0	+38 47	−1.25	−2.4	2.408	2.309	24.7	72.2	12.5	21.2
21	4 21.8	+40 30	−1.29	−1.4	2.337	2.343	25.0	77.9	12.6	21.2

Table 10. (Continued.)

Date (0$^{\rm h}$ET)	α_{2000}	δ_{2000}	Variation		Δ	r	Phase	Elong.	H	h
	h m	° ′	m	′			°	°		
2014 Aug. 31	4 37.1	+42 08	−1.35	−0.5	2.263	2.379	25.0	83.9	12.7	21.2
Sept. 10	4 50.4	+43 40	−1.41	+0.4	2.188	2.415	24.6	90.4	12.7	21.1
20	5 01.3	+45 09	−1.48	+1.3	2.114	2.453	24.0	97.3	12.8	21.0
30	5 09.2	+46 33	−1.57	+2.0	2.042	2.492	22.9	104.7	12.9	21.0
Oct. 10	5 13.6	+47 52	−1.67	+2.5	1.975	2.532	21.4	112.5	13.0	20.9
20	5 14.0	+49 03	−1.79	+2.8	1.916	2.572	19.4	120.8	13.0	20.8
30	5 10.3	+50 01	−1.91	+2.7	1.869	2.613	17.1	129.2	13.1	20.7
Nov. 9	5 02.4	+50 40	−2.02	+2.3	1.838	2.655	14.6	137.6	13.2	20.6
19	4 51.4	+50 53	−2.10	+1.5	1.826	2.697	12.1	145.1	13.3	20.5
29	4 38.7	+50 36	−2.12	+0.4	1.837	2.739	10.2	150.5	13.5	20.5
Dec. 9	4 26.2	+49 48	−2.07	−0.6	1.873	2.782	9.5	152.1	13.6	20.6
19	4 15.5	+48 35	−1.96	−1.5	1.935	2.825	10.3	149.1	13.8	20.7
29	4 07.8	+47 06	−1.82	−2.1	2.022	2.868	11.9	142.9	14.0	20.9
2015 Jan. 8	4 03.6	+45 32	−1.67	−2.4	2.132	2.911	13.8	135.0	14.3	21.1
18	4 02.9	+43 59	−1.52	−2.4	2.261	2.955	15.5	126.5	14.5	21.3
28	4 05.3	+42 33	−1.38	−2.2	2.408	2.998	16.9	117.9	14.8	21.5
Feb. 7	4 10.5	+41 17	−1.26	−1.9	2.567	3.041	17.8	109.5	15.0	21.7
17	4 17.9	+40 11	−1.15	−1.5	2.735	3.084	18.3	101.3	15.3	21.9
27	4 27.1	+39 14	−1.06	−1.1	2.910	3.127	18.4	93.3	15.5	22.1
Mar. 9	4 37.8	+38 26	−0.98	−0.7	3.087	3.170	18.2	85.7	15.7	22.2
19	4 49.6	+37 44	−0.90	−0.3	3.264	3.213	17.7	78.2	15.9	22.4
29	5 02.4	+37 07	−0.84	+0.1	3.439	3.255	16.9	71.1	16.1	22.5
Apr. 8	5 16.0	+36 33	−0.78	+0.4	3.609	3.297	15.9	64.1	16.3	22.6
18	5 30.0	+36 01	−0.73	+0.7	3.773	3.339	14.7	57.3	16.5	22.6
28	5 44.4	+35 29	−0.68	+1.0	3.928	3.380	13.3	50.6	16.7	22.7
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Sept. 25	9 01.1	+25 22	−0.31	+3.1	4.501	3.955	11.4	51.4	18.0	23.3
Oct. 5	9 09.7	+24 44	−0.30	+3.2	4.410	3.989	12.4	59.1	18.0	23.3
15	9 17.2	+24 11	−0.30	+3.3	4.306	4.023	13.2	67.1	18.0	23.3
25	9 23.5	+23 42	−0.30	+3.4	4.193	4.057	13.7	75.4	17.9	23.3
Nov. 4	9 28.5	+23 19	−0.30	+3.5	4.073	4.090	14.0	84.0	17.9	23.2
14	9 32.0	+23 03	−0.30	+3.7	3.949	4.123	13.9	93.1	17.9	23.2
24	9 34.0	+22 54	−0.31	+3.8	3.826	4.155	13.4	102.6	17.9	23.1
Dec. 4	9 34.1	+22 52	−0.32	+3.9	3.708	4.187	12.6	112.6	17.8	23.0
14	9 32.5	+22 57	−0.34	+4.0	3.600	4.218	11.3	123.0	17.8	22.9
24	9 29.0	+23 08	−0.36	+4.1	3.507	4.249	9.6	133.9	17.8	22.8
2016 Jan. 3	9 23.7	+23 24	−0.38	+4.2	3.436	4.279	7.6	145.1	17.8	22.7

NOTE: Average extrapolated correction ΔT = ET − UT for the period of time 2010-2015 is expected to be about +66 seconds; see `http://tycho.usno.navy.mil/leapsec.html`.

such data from 2010-2013 and early 2014 will provide particularly valuable information. The results of the proposed monitoring campaign will also serve to test whether in mid-2014 — as in mid-1899 — the comet undergoes a moderate, early post-perihelion outburst, and whether its light curve during the second half of 2014 resembles that from 1899/1900 and 1906, and during the second half of 2015 that from late 2008 and early 2009.

9. Conclusions

The results of a search for historical records of naked-eye detections of super-massive explosions of comet 17P/Holmes suggest that the 1892-1893 and 2007 events were manifestations of a systematic, long-term pattern rather than isolated, unrelated flare-ups. Based on the properties of the 1892-1893 and 2007 explosions and dependent on the integration of the comet's motion back in time to about 1000 BC, the search was limited to 210-day long orbital arcs, from 90 days to 300 days after perihelion during each of the nearly 300 returns to the sun in the course of the three millennia. Because the perihelion distance and orbital period have been decreasing with time on account of the Jovian perturbations, the comet was in the past generally farther from the sun and the earth at the times of the expected super-massive explosions and therefore appearing somewhat fainter than in 2007. The search has suggested four possible sightings of comet 17P — in September 305, July-August 836, August 1269, and 1621 May 22. The most promising candidate is the object in AD 305, which was described in three Chinese historical chronicles as a sparkling star (*po-hsing*), for which no tail was mentioned and whose celestial position closely agrees with the ephemeris. The locations in the sky of the other three candidates were not pinpointed accurately enough to offer positive identifications. In each of the four cases, comet 17P should have reached about magnitude 4 for an explosion as powerful as the 2007 megaburst. Given that stronger explosions cannot be ruled out and that the likelihood of detection increases with increasing visual prominence, the comet may have been brighter than magnitude 4 during at least some of the recorded sightings. And given that the rate of conduction of the incident solar energy into the interior of the comet's nucleus depends on the orbital dimensions, the detection probability of the described search covering two millennia into the past is estimated at averaging between 10 and 50 percent. It is believed that the exploding comet 17P has never become a truly spectacular object and it certainly is not a plausible candidate for the Star of Bethlehem, even though one of its predicted returns to the sun occurred close to the conjectured time of the birth of Christ.

During the next 100 years, the orbit of comet 17P/Holmes will be subjected to no major variations. The most noticeable perturbations will result following an encounter with Jupiter in April 2051. Of greater interest is the physical behavior and the degree of activity of the comet following the megaburst of 2007. Since evidence from the apparitions 1899-1906 suggests that comet 17P was "settling down" very gradually after the super-massive explosion of 1892-1893, it is deemed desirable that — during the complete revolution about the sun, up to and including the year 2015 — the temporal variations in the comet's normalized integrated brightness be monitored to ascertain the extent to which 17P will mimic its post-explosion evolution more than 100 years before. An ephemeris and limited information on the light curve, based on the experience with the comet's behavior in 1899-1900, 1906, and late 2008 and early 2009, is hereinabove provided to facilitate such an observing campaign.

The history of super-massive explosions of comet 17P/Holmes as revealed by the results of the search for their observations over extended periods of time in the past (a) is consistent with the physical model proposed in Paper 2 for the mechanism of their formation; (b) strengthens the arguments that substantiate and underpin the vital importance of crystallization of gas-laden amorphous water ice in subsurface reservoirs as a trigger of these events; and (c) contributes to the understanding of the nature and evolution of the layered morphology in cometary nuclei. Finally, because the super-massive explosions represent a manifestation of nuclear fragmentation, as emphasized in Paper 2, their history in comet 17P shows the role they play in the process of comet aging and disintegration.

Appendix: Definitive Visual Light Curve of Comet 17P/Holmes 1892-2009

The work on the brightness of comet 17P undertaken in the previous papers of this series (Sekanina 2008b, 2009a, Paper 1) is here completed and the results summarized. The light curve of 17P is a plot of its integrated visual magnitude $H_\Delta(t)$ — defined as that recorded by an average observer and normalized to a geocentric distance $\Delta = 1$ AU by a Δ^{-2} power law — as a function of time t reckoned from the comet's nearest perihelion passage. The average observer has been defined by averaging the sampled naked-eye magnitudes reported by 52 participants to the *International Comet Quarterly* following the onset of the megaburst on 2007 October 23 (Sekanina 2009a). The common magnitude system established in this way has then been used to "calibrate" each observer's set of magnitudes by applying a constant personal magnitude correction. Subsequently, this common magnitude system has been extended to fainter magnitudes by linking the post-megaburst naked-eye brightness estimates with telescopic visual and CCD brightness data, reported as "total" magnitudes and made with the same instrumentation both before and after the 2007 event. Each visual and CCD telescopic observer with each instrument used in 2007-2009 has been assigned a personal/instrumental correction to convert the reported magnitude to the common system. This approach has further been extended to the apparitions 1986, 1993, and 2000 by comparing and calibrating the magnitudes reported by the same observers using the same instruments at more than one apparition.

All magnitudes of comet 17P reported from the apparitions 1964, 1970, and 1979 were referred to by the observers as "nuclear" (Paper 1) and they have not been considered here as input to the light curve. The comet was missed at its returns 1913-1957 and the only remaining pre-1986 brightness estimates are those from the apparitions 1892 (the discovery apparition), 1899, and 1906. The comet's naked-eye detections, including a few naked-eye magnitudes, reported by several observers in 1892 and 1893 have been used (Sekanina 2008b), as they are believed to be crudely compatible (to perhaps ±0.5 mag or so) with the 2007 naked-eye data, thus providing meaningful light-curve comparison on a time scale of more than 100 years. These results have also been employed to calibrate some telescopic visual-magnitude observations at the same apparition. The comet's brightness did not reach the naked-eye detection threshold in 1899-1900 and 1906, and the only possibility of approximately calibrating the magnitude observations available from these apparitions is by employing Barnard's (1932) data obtained with the 102-cm refractor of the Yerkes Observatory, whose magnitude correction was investigated in considerable detail by Marcus (1983). This correction was also used in Paper 1 to calibrate Perrine's (1899, 1900) visual-brightness estimates from 1899-1900 and Wolf's and Kopff's photographic-brightness estimates from 1906 (*e.g.*, Wolf 1906).

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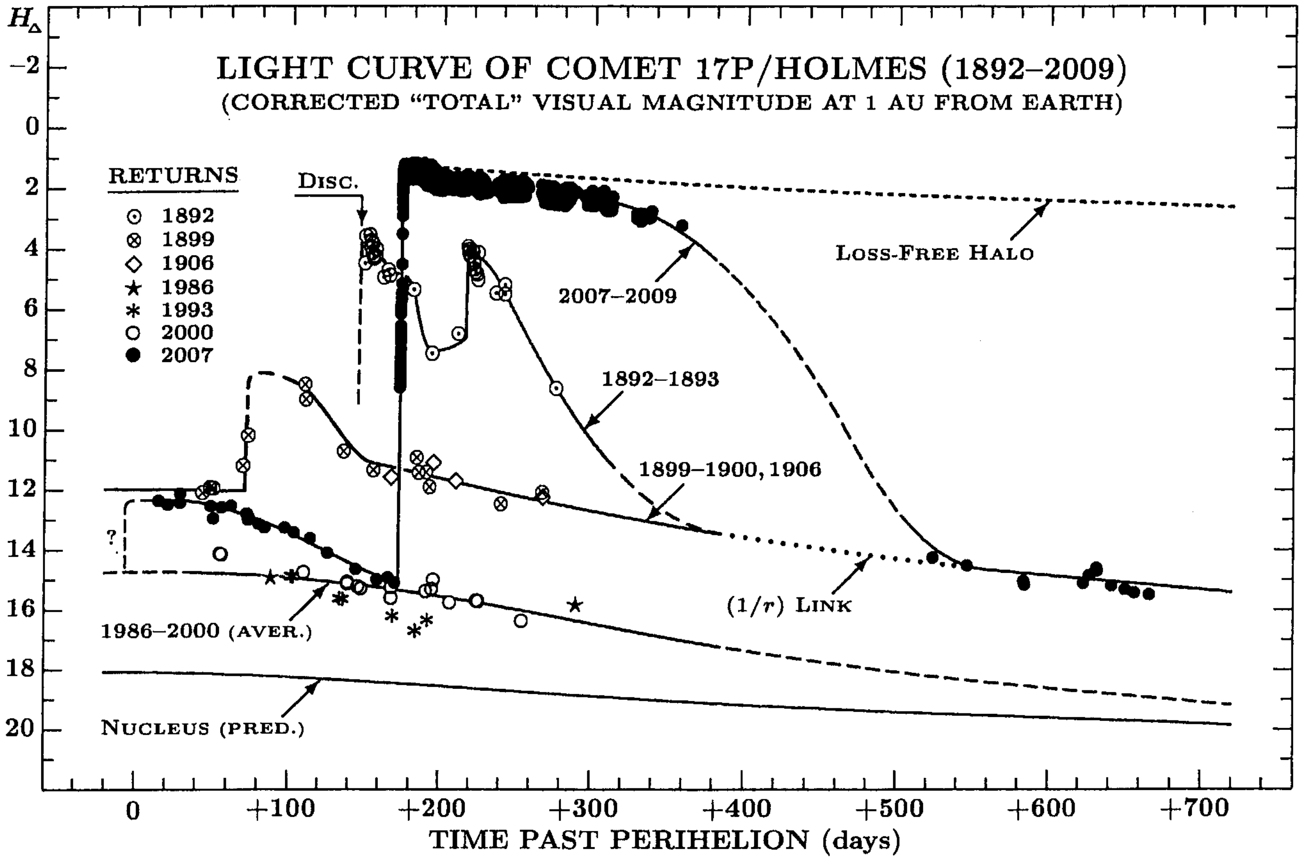

Figure A-1. The definitive visual light curve of comet 17P/Holmes at seven apparitions, based on 1610 data points from the period 1892 to 2009. The magnitudes H_Δ, normalized to a unit geocentric distance, have been corrected for personal and instrumental effects, with the corrections listed in Table A-1. The observations are represented by the apparition-specific symbols, with the discovery in 1892 marked and poorly determined light-curve segments depicted by long dashes. A hypothetical loss-free halo curve, shown with short dashes, applies to a case in which no dust particles injected into the atmosphere during the megaburst have escaped. The bottom curve is a predicted normalized magnitude of a spherical nucleus, at a zero phase angle, which is 3.3 km in diameter and whose geometric albedo is 4 percent. Highlighted as the $(1/r)$ link with the dotted curve is the assumed fit between the post-perihelion light curve for 1899-1900 and 1906 and the post-megaburst light curve in late 2008 and early 2009. A possible minor precursor outburst, before the comet was recovered in 2007, is indicated by a question mark.

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The definitive visual light curve of comet 17P/Holmes, the primary product of the described effort, is presented in Figure A-1. The plot illustrates the enormous variations in the normalized integrated brightness during and after the super-massive explosions in 1892 and 2007, as well as the apparently gradual "recuperation" after the two episodes of the 1892-1893 event, a process that may have taken at least two revolutions around the sun. There is a nearly constant difference of about 4 magnitudes along much of the post-perihelion branch of the orbit between the post-explosion apparitions 1899 and 1906 on the one hand and the quiescent apparitions 1986-2000 on the other hand. There is also an intriguing possibility that a relatively minor outburst, with an amplitude of ~ 2 magnitudes, took place before or very near the 2007 perihelion, just prior to the comet's recovery on May 13. If so, the brightness observations made over a period of about five months, before October 23, covered the subsiding branch of this early outburst — a precursor to the main event. The megaburst occurred at a time when the comet was just about to reach its 1986-2000 quiescent

Table A-1. Personal/instrumental magnitude corrections for observers of comet 17P/Holmes 1892-2009.

Return to sun	Observer(s) or observing project	Correction (mag)[a]	Observing technique	Instrument used	Location and/or country
1892	Backhouse, T. W.	−0.3	visual	naked eye[b]	Sunderland, U.K.
	Barnard, E. E.	0.0	visual	naked eye	Lick Observatory, Calif., U.S.A.
		−2.0	visual	8-cm refractor	"
	Coit, J. B.	0.0	visual	naked eye	Boston University, Mass., U.S.A.
	Holetschek, J.	−0.7	visual	4-cm comet seeker	Vienna Observatory, Austria
	Kammermann, A.	−1.7	visual	25-cm refractor	Geneva Observatory, Switzerland
	Kobold, H. A.	0.0	visual	naked eye	Strassburg Observatory, Germany
	Lovett, E. O.	0.0	visual	naked eye	Leander McCormick Observatory, Va., U.S.A.
	Updegraff, M.	0.0	visual	naked eye	Columbia Observatory, Mo., U.S.A.
1899	Barnard, E. E.	−3.0	visual	102-cm *f*/19 refractor	Yerkes Observatory, Wisc., U.S.A.
	Perrine, C. D.	−2.0	visual	91-cm *f*/19.3 refractor	Lick Observatory, Calif., U.S.A.
1906	Kopff, A.	−2.3	photogr.	41-cm *f*/5 refractor	Königstuhl Observatory, Heidelberg, Germany
	Wolf, M.	−2.3	photogr.	41-cm *f*/5 refractor	Königstuhl Observatory, Heidelberg, Germany
		−2.3	photogr.	72-cm *f*/4 reflector	"
1986	Gehrels, T.; Scotti, J. V.	−0.75	CCD	90-cm *f*/5.3 reflector[c]	Kitt Peak Observatory, Ariz., U.S.A.
	Gibson, J. B.	−0.75	CCD	150-cm *f*/8.75 reflector	Palomar Observatory, Calif., U.S.A.
1993	Nakamura, A.	−0.05	CCD	60-cm *f*/5.8 reflector	Kuma Kogen Observatory, Japan
	Scotti, J. V.	−0.75	CCD	90-cm *f*/5.3 reflector[c]	Kitt Peak Observatory, Ariz., U.S.A.
2000	Hotta, M.	−0.05	CCD	25-cm *f*/6 reflector	Konan Observatory, Japan
	Ikari, Y.	+0.25	CCD	25-cm *f*/6.3 reflector	Moriyama Observatory, Japan
	Jäger, M.	+1.0	photogr.	30-cm *f*/3.3 camera	near Vienna, Austria
	Kadota, K.	−0.3	CCD	18-cm *f*/5.5 reflector	Ageo Observatory, Japan
	Nakamura, A.	−0.05	CCD	60-cm *f*/5.8 reflector	Kuma Kogen Observatory, Japan
	Sugie, A.	−0.3	CCD	60-cm *f*/3.7 reflector	Dynic Astronomical Observatory, Japan
2007	Biver, N.	−0.22	visual	naked eye	France
		−0.27	visual	5-cm binoculars	"
	Bortle, J. E.	−0.18	visual	naked eye	Stormville, N.Y., U.S.A.
		−0.08	visual	2.5-cm binoculars	"
		−0.13	visual	5-cm *f*/4 monocular	"
		−0.20	visual	5-cm binoculars	"
	Bouma, R. J.	−0.01	visual	naked eye	The Netherlands
		+0.10	visual	2.8-cm *f*/2 refractor	"
		−0.10	visual	5-cm binoculars	"
	Brukhanov, I. S.	−0.45	visual	4-cm binoculars	Belarus
	Bus, E. P.	+0.12	visual	naked eye	The Netherlands
		+0.19	visual	3-cm binoculars	"
		+0.25	visual	4.4-cm binoculars	"
	Carvajal Martinez, J.	0.00	visual	naked eye	Spain
		0.00	visual	2-cm binoculars	"
	Catalina Sky Survey	+0.20	CCD	68-cm *f*/1.9 Schmidt	Catalina Mountains, Ariz., U.S.A.
	Cernis, K. T.	−0.15	visual	naked eye	Lithuania
		0.00	visual	5-cm binoculars	"
		−0.22	visual	5-cm *f*/4 refractor	"
	Comello, G.	−0.25	visual	naked eye	The Netherlands
		−0.42	visual	5-cm binoculars	"
	Creed, P. J.	0.00	visual	naked eye	Ohio, U.S.A.
	Dahle, H.	+0.10	visual	naked eye	Norway
	Diepvens, A.	−0.20	visual	5-cm binoculars	Belgium
	Dijk, E. van	0.00	visual	naked eye	The Netherlands
		+0.11	visual	2.8-cm *f*/2 refractor	"
		+0.10	visual	5-cm binoculars	"
		−0.10	visual	6-cm binoculars	"
	Giambersio, A.	−0.10	visual	naked eye	Italy
	Gilein, G.	−0.20	visual	naked eye	The Netherlands
	Gobet, F.	−0.54	visual	naked eye	Cestas, France
	Goiato, M. A. C.	−0.30	visual	5-cm binoculars	Brazil

Table A-1. (Continued.)

Return to sun	Observer(s) or observing project	Correction (mag)[a]	Observing technique	Instrument used	Location and/or country
2007	Gonzalez, J. J.	+0.25	visual	naked eye	Spain
		−0.10	visual	3-cm opera glass	"
		+0.33	visual	3-cm refractor	"
		−0.24	visual	10-cm binoculars	"
	Granslo, B. H.	+0.11	visual	naked eye	Norway
		0.00	visual	1.8-cm *f*/4 refractor	"
		0.00	visual	3-cm refractor	"
		−0.02	visual	5-cm binoculars	"
		−0.10	visual	5-cm *f*/4 refractor	"
	Green, D. W. E.	−0.01	visual	naked eye	near Cambridge, Mass., U.S.A.
		−0.08	visual	5-cm refractor	"
	Guido, E., *et al.*	0.0	CCD	25-cm *f*/3.4 reflector[d]	Remote Astron. Soc. Obs., N.M., U.S.A.
	Hale, A.	0.00	visual	naked eye	Cloudcroft, N.M., U.S.A.
	Hasubick, W.	−0.10	visual	naked eye	Germany
	Henríquez Santana, J. A.	+0.20	CCD	20-cm *f*/9 Cassegrain	Tenerife, Canary Islands, Spain
	Horálek, P.	+0.15	visual	naked eye	Czech Republic
	Hornoch, K.	+0.02	visual	naked eye	Lelekovice, Czech Republic
		0.00	visual	5-cm monocular	"
	Hsieh, H. H., *et al.*	0.00	CCD	SuperWASP-North[e]	La Palma, Canary Islands, Spain
	Ivanov, V. M.	−0.20	visual	naked eye	Russia
		−0.10	visual	3-cm *f*/6 refractor	"
	Kadota, K.	−0.30	CCD	25-cm *f*/5.0 reflector	Ageo Observatory, Japan
	Kammerer, A.	−0.40	visual	naked eye	Germany
		0.00	visual	6.3-cm binoculars	"
	Kanai, K.	−0.50	visual	naked eye	Isesaki, Japan
		−0.30	visual	3.5-cm binoculars	"
	Karhula, T.	−0.15	visual	naked eye	Virabo, Sweden
	King, B.	0.0	visual	naked eye	Duluth, Minn., U.S.A.
		0.0	visual	25-cm reflector	"
	Koukal, J.	−0.10	visual	naked eye	Czech Republic
		−0.05	visual	6-cm *f*/6 Maksutov	"
		−0.20	visual	6-cm *f*/6 reflector	"
	Labordena, C.	−0.08	visual	naked eye	Castellon, Spain
		+0.22	visual	3-cm binoculars	"
	Lehký, M.	−0.12	visual	naked eye	Hradec Králové, Czech Republic
		−0.10	visual	5-cm binoculars	"
	Maňák, R.	−0.05	visual	3-cm binoculars	Lipov, Czech Republic
	Meyer, M.	+0.05	visual	naked eye	Germany
		+0.05	visual	1.5-cm opera glass	"
		+0.05	visual	1.5-cm binoculars	"
		−0.20	visual	5-cm binoculars	"
	Mitsuma, S.	−0.10	visual	naked eye	Honjo, Japan
		−0.30	visual	3.5-cm binoculars	"
	Miyazaki, O.	−0.06	visual	naked eye	Ishioka, Japan
		−0.30	visual	2.1-cm binoculars	"
		−0.30	visual	3.2-cm binoculars	"
		−0.05	visual	5-cm binoculars	"
		−0.60	visual	5-cm refractor	"
	Morel, P.	−0.53	visual	2-cm binoculars	France
		−0.20	visual	8-cm binoculars	"
	Morris, C. S.	+0.17	visual	naked eye	Calif., U.S.A.
		+0.08	visual	5-cm binoculars	"
	Mount Lemmon Survey	−0.9	CCD	150-cm Cassegrain	Catalina Mountains, Ariz., U.S.A.
	Nagai, Y.	−0.10	visual	naked eye	Gunma, Japan
		−0.50	visual	1.8-cm refractor	"
		−0.50	visual	3.5-cm binoculars	"
		0.0	CCD	5.4-cm *f*/6 camera	"
	Nagashima, K.	−0.30	visual	5-cm binoculars	Nara, Japan
	Nagy, M.	−0.15	visual	naked eye	Csenger, Hungary
	Naves, R.; Campás, M.	+0.4	CCD	30-cm Schmidt-Cass.	Montcabre Observatory, Barcelona, Spain

Table A-1. (Continued.)

Return to sun	Observer(s) or observing project	Correction (mag)[a]	Observing technique	Instrument used	Location and/or country
2007	Nevski, V. S.	−0.03	visual	naked eye	Vitebsk, Belarus
		−1.5	CCD	30-cm *f*/5 reflector	"
	Novichonok, A. O.	−0.10	visual	naked eye	Russia
		−0.23	visual	5-cm binoculars	"
	Nowak, G. T.	−0.10	visual	naked eye	Vt., U.S.A.
	O'Meara, S.	+0.30	visual	5-cm monocular	Mass., U.S.A.
	Paradowski, M. L.	0.00	visual	naked eye	Poland
		−0.08	visual	2.4-cm binoculars	"
		+0.05	visual	2.4-cm refractor	"
		+0.15	visual	3.5-cm binoculars	"
		+0.15	visual	5-cm binoculars	"
		0.00	visual	6-cm binoculars	"
		−0.05	visual	6.7-cm *f*/6 refractor	"
		+0.16	visual	10-cm binoculars	"
		0.00	visual	20-cm *f*/6 reflector	"
	Pereira, A. J. S.	+0.01	visual	naked eye	Portugal
		−0.17	visual	2.2-cm *f*/11 refractor	"
	Pilz, U.	−0.40	visual	2.4-cm binoculars	Leipzig, Germany
	Rietveld, H.	0.00	visual	naked eye	The Netherlands
		+0.05	visual	3-cm binoculars	"
	Rinner, C.; Kugel, F.	−1.0	CCD	50-cm *f*/3 reflector	Chante-Perdrix Obs., Dauban, France
	Rzepka, Z.	−0.30	visual	6-cm binoculars	Lublin, Poland
		−0.40	visual	8-cm binoculars	"
	Sánta, G.	−0.15	visual	naked eye	Kisujszállás, Hungary
	Sárneczky, K.	−0.65	visual	naked eye	Budapest, Hungary
	Scarmato, T.	+0.35	visual	naked eye	Calabria, Italy
	Scholten, A. H.	+0.12	visual	naked eye	The Netherlands
		−0.05	visual	1.5-cm *f*/3 refractor	"
	Scotti, J. V.; Tubbiolo, A. F.	−0.75	CCD	90-cm *f*/3 reflector[c]	Kitt Peak, Ariz., U.S.A.
	Seargent, D. A. J.	−0.26	visual	naked eye	The Entrance, N.S.W., Australia
		−0.40	visual	2.5-cm binoculars	"
	Shurpakov, S. E.	0.00	visual	naked eye	Belarus
		−0.40	visual	3-cm *f*/6 refractor	"
		−0.25	CCD	8-cm *f*/7 refractor	"
	Skilbrei, O.	+0.30	visual	naked eye	Norway
	Souza, W. C. de	−0.30	visual	3-cm binoculars	Sao Paulo, Brazil
		−0.40	visual	4-cm opera glass	"
		−0.55	visual	5-cm binoculars	"
		−0.50	visual	8-cm binoculars	"
	Srba, J.	−0.2	CCD	14.5-cm *f*/8 reflector	Vsetín, Czech Republic
	Szabó, S.	−0.15	visual	4.2-cm binoculars	Sopron, Hungary
	Tóth, Z.	−0.15	visual	naked eye	Hungary
	Trigo-Rodríguez, J. M., *et al.*	+0.25	CCD	1.6-cm *f*/3.5 camera[f]	Spain
	Tsumura, M.	0.00	visual	naked eye	Wakayama, Japan
		0.00	visual	2-cm *f*/5 refractor	"
		−0.6	CCD	35-cm *f*/14 Cassegrain	"
	Wheeler, R. O.	−0.30	visual	naked eye	Okla., U.S.A.
	Yoshida, S.	+0.04	visual	naked eye	Kanagawa, Japan
		−0.20	visual	5-cm refractor	"
		−0.20	visual	6.6-cm refractor	"
	Yoshimoto, K.	−0.10	visual	naked eye	Yamaguchi, Japan
		−0.15	visual	3.5-cm binoculars	"
		−0.50	visual	5-cm refractor	"

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[a] This correction is added to the reported magnitude to convert the observer's apparent magnitude to the common system applied; the minus sign indicates the observer underestimated the brightness, and vice versa.

[b] Also field-glasses and 11-cm refractor.

[c] The magnitude correction for images taken with the participation of J. V. Scotti (1986, 1993, and 2007) is assumed to be the same, even though the instrument was reconfigured and a new primary mirror installed in 2002; see `http://spacewatch.lpl.arizona.edu/scopes.html`.

[d] And 30-cm *f*/12 reflector.

[e] SuperWASP is an extrasolar planet detection facility, consisting of two (northern and southern) robotic observatories operating continuously. Each consists of eight 11-cm *f*/1.8 cameras and 2048 × 2048 CCD detectors. For more information see `http://www.superwasp.org`.

[f] This camera is part of the Spanish Meteor and Fireball Network, consisting of a system of "fish-eye" all-sky lenses with CCD detectors.

state. Finally, the figure shows the surprising degree of correspondence between the comet's post-perihelion brightness in 1899-1900 and 1906 on the one hand and the "residual" post-megaburst brightness in late 2008 and early 2009. The empirical ($1/r$) link, referred to in Sec. 8 and used as a predictive tool in Table 10, is prominently depicted in Figure A-1.

The magnitude corrections applied to all selected observers and their instruments — the key information necessary for the construction of the light curve in Figure A-1 — are listed in Table A-1. Only consistent data sets have been selected. The light curve for late 2008 and early 2009 (500 to 700 days past perihelion) is dominated by the "total" magnitudes reported by the Catalina Sky Survey group and by K. Kadota (see Table A-1).

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Tabulation of Comet Observations

Descriptive Information, to complement the Tabulated Data (all times UT):
See the July 2001 issue (page 98) for explanations of the abbreviations used in the descriptive information.

◇ *Comet 22P/Kopff* ⟹ 2009 Sept. 24.51: 1′-long jet in p.a. 170° [TSU02] Oct. 12.51-12.52: LONEOS PKS 2345-167 sequence used for comp.-star mags [YOS02]. Nov. 19.47-19.49: trace of jet visible in p.a. 160°; LONEOS PG 2213-006 sequence used for comp.-star mags [YOS02].

◇ *Comet 29P/Schwassmann-Wachmann* ⟹ 2009 Nov. 18.11: "in evolution after the recent new outburst" [GON05].

◊ *Comet 30P/Reinmuth* ⟹ 2009 Nov. 24.08: nearby field stars checked via Digitized Sky Survey; comp.-star mags taken from Henden photometry near V650 Ori; motion checked over a 45-min period; mountain location, very clear sky [GON05].

◊ *Comet 81P/Wild* ⟹ 2009 Nov. 18.14 and Dec. 12.16: elongated coma [GON05]. Dec. 27.17: city lights [PAR03].

◊ *Comet 88P/Howell* ⟹ 2009 Nov. 2.95: moonlight and clouds interfering [AMO01]. Nov. 18.78: elongated wide coma with faint outer region; alt. 12° [GON05]. Dec. 4.78: alt. 14° [GON05].

◊ *Comet 107P/Wilson-Harrington* ⟹ 2009 Nov. 7.40-7.41: LONEOS Mark 509 sequence used for comp.-star mags [YOS02]. Nov. 19.43-19.45: LONEOS [TSM84].37-51 sequence used for comp.-star mags [YOS02]. Nov. 26.52-26.54: Landolt PG 2213-006 sequence used for comp.-star mags [YOS02].

◊ *Comet 118P/Shoemaker-Levy* ⟹ 2009 Nov. 18.19 and Dec. 12.03: nearby field stars checked via Digitized Sky Survey; comp.-star mags taken from Henden photometry near V650 Ori [GON05]. Dec. 12.03: mountain location, very clear sky [GON05].

◊ *Comet 144P/Kushida* ⟹ 2009 Jan. 15.48: coma enhanced by Swan-band filter [MAT08].

◊ *Comet C/2006 W3 (Christensen)* ⟹ 2009 Aug. 14.54: coma well condensed [MAT08]. Dec. 4.77: alt. 15° [GON05].

◊ *Comet C/2007 N3 (Lulin)* ⟹ 2009 Jan. 24.71: in 25×100 B, bright disk-shaped coma; no stellar 'nucleus' visible [MAT08].

◊ *Comet C/2007 Q3 (Siding Spring)* ⟹ 2009 Dec. 20.18: "in evolution after the recent little outburst; near-stellar central cond. of mag 11.8 (ref: Tycho-2); mountain location, very clear sky [GON05]. Dec. 27.19: city lights [PAR03].

◊ *Comet C/2009 K2 (Catalina)* ⟹ 2009 Apr. 21.54: comet 4 mags brighter than predicted; comp. stars have mag 9.46 and 10.16; alt. 11°; coma enhanced w/ Swan-band filter and extends to dia. 5′ [MAT08]. May 5.79: bright and large. Predicted magnitude 13.4 [MAT08]. May 13.42: alt. 25°; coma enhanced w/ Swan-band filter ; coma appears as a large circular haze; w/ 25×100 B, comet easily outshines galaxy NGC 6744, 2° to the NW [MAT08]. May 26.50: in a 30-in telescope, coma appears asymmetrical [MAT08]. June 10.37: more condensed than the larger NGC 5128 (thus easier to see but still apparently fainter) [MAT08]. July 19.86: very low alt. (5 deg) [SZA]. Aug. 14.43: zodiacal-light interference [MAT08].

◊ *Comet C/2008 T2 (Cardinal)* ⟹ 2009 June 14.37: coma enhanced by Swan-band filter [MAT08].

◊ *Comet C/2009 E1 (Itagaki)* ⟹ 2009 Mar. 17.42: 8° alt. [MAT08].

◊ *Comet P/2009 Q4 (Boattini)* ⟹ 2009 Nov. 18.15: elongated coma; nearby field stars checked via Digitized Sky Survey; comp.-star mags taken from Henden photometry near AK Cnc; mountain location, very clear sky [GON05]. Nov. 24.15: elongated coma; nearby field stars checked via Digitized Sky Survey; comp.-star mags taken from Henden photometry near AK Cnc [GON05].

◊ *Comet P/2009 Q5 (McNaught)* ⟹ 2009 Nov. 19.54: LONEOS Rose SGP sequence used for comp.-star mags [YOS02].

◊ *Comet P/2009 T2 (La Sagra)* ⟹ 2009 Dec. 4.79: mountain location, very clear sky; nearby field stars checked via Digitized Sky Survey; comp.-star mags taken from Henden photometry near DZ Psc [GON05].

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Key to observers with observations published in this issue, *with 2-digit numbers between Observer Code and Observer's Name indicating source [16 = Japanese observers (via Akimasa Nakamura, Kuma, Ehime); 32 = Hungarian observers (via Krisztián Sárneczky, Budapest); etc.]:*

*AGU01		Salvador Aguirre, Sonora, Mexico
AMO01		Alexandre Amorim, Brazil
CHR	18	Antoni Chrapek, Pikulice, Poland
CSU	32	Mátyás Csukás, Salonta, Romania
DES01		Jose G. de Souza Aguiar, Brazil
DIE02		Alfons Diepvens, Belgium
DOM	32	Gábor Dömény, Szekszárd, Hungary
FIL04	18	Marcin Filipek, Poland
GON05		J. J. Gonzalez, Asturias, Spain
HAS02		Werner Hasubick, Germany
KER01	32	János Kernya, Hungary
KES01		Sándor Keszthelyi, Pécs, Hungary
KIS03	18	Adam Kisielewicz, Poland
KUL02	32	Zoltán Kuli, Budapest, Hungary
KUT	49	Walter Kutschera, Germany
KWI	18	Maciej Kwinta, Krakow, Poland
LAB02		Carlos Labordena, Spain
LEG	18	Marian Legutko, Gliwice, Poland
LEH		Martin Lehky, Czech Republic
MAR12	18	Leszek Marcinek, Poland
MAT08		Michael Mattiazzo, S. Australia
MEY		Maik Meyer, Germany
MOS01	18	Waclaw Moskal, Poland
NAG04	16	Kazuro Nagashima, Nara, Japan
PAR03		Mieczyslaw L. Paradowski, Poland
PIL01		Uwe Pilz, Leipzig, Germany
POW01	18	Jacek Powichrowski, Poland
SAD	18	Piotr Sadowski, Poland

SAN07	32	Gábor Sánta, Hungary
SAR02	32	Krisztián Sárneczky, Hungary
SCI		Tomasz Sciezor, Poland
SEA		David A. J. Seargent, Australia
SIE01	18	Marcin Siekierko, Poland
SIK01	18	Mieczyslaw Sikora, Poland
SMY	18	Jaroslaw Smyslo, Poland
SOU01		Willian C. de Souza, Brazil
SWI	18	Mariusz Swietnicki, Poland
SWI01	18	Stanislaw Swierczynski, Poland
SZA		Sándor Szabó, Sopron, Hungary
TOT03	32	Zoltán Tóth, Hungary
TSU02	16	Mitsunori Tsumura, Japan
UJV	32	Antal Ujvárosy, Hungary
VAS06	32	László Vastagh, Nőtincs, Hungary
WYA		Chris Wyatt, Australia
YOS02	16	Katsumi Yoshimoto, Japan

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NOTE: *The tabulated CCD data summary begins on page 39 of this issue.*

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Tabulated Visual-Data Summary

As begun the July 2007 issue, we now publish summaries of contributed tabulated data instead of publishing each line of observation that is contributed to the *ICQ* (with rare exceptions, as with comets C/2006 P1 and 17P in the last couple of years); the following format serves the purpose of summarizing all the comets that had data reported with their observational arcs for each observer. The full 80-character observation records are posted at the *ICQ* website (`http://www.cfa.harvard.edu/icq/icqobs.html`), and are available upon request to the *ICQ* Editor.

The tabulation below lists, for each comet, the first and last observation (with associated total visual magnitude estimate) for each observer, listed in alphabetical order of the observers within each comet's listing (the usual 3-letter, 2-digit observer code coming under the column `Obs.`, whose key is provided above). The final column (separated by a slash, /, from the observer code) provides the number of individual 80-character observation records entered into the *ICQ* archive from that observer for the particular comet for this issue; when only one observation was submitted by a specific observer for a given comet, the last column is left blank (with no slash mark after the observer code).

Comet 22P/Kopff

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 06 29.01	12.3	2009 09 20.81	11.7	CHR / 11
2009 11 08.83	11.7			GON05
2009 09 23.89	11.6			HAS02
2009 11 16.80	11.7			LAB02
2009 05 05.81	9.9	2009 08 14.55	10.5	MAT08/ 2
2009 07 19.96	10.5:	2009 08 21.90	11.5	SAN07/ 2
2009 05 24.02	10.2			SAR02
2009 07 24.92	11.1:	2009 07 29.97	11.2:	SCI / 5
2009 08 21.90	11.9	2009 09 01.07	11.3	SZA / 2
2009 07 16.94	10.8			TOT03
2009 11 09.41	14.0	2009 11 15.43	13.4	WYA / 2

Comet 29P/Schwassmann-Wachmann

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 11 18.11	11.8	2009 12 12.15	12.0	GON05/ 3
2009 01 20.85	11.8			KER01
2009 01 03.86	11.3	2009 02 27.76	11.6	SAN07/ 4
2009 01 16.83	11.2			TOT03
2009 11 25.72	13.2			WYA

Comet 30P/Reinmuth

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 11 24.08	15.2			GON05

Comet 67P/Churyumov-Gerasimenko

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 04 25.81	11.6			SAN07
2009 03 21.79	11.4			TOT03

Comet 81P/Wild

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 11 09.48	11.0			AGU01
2009 12 26.26	11.6			DIE02
2009 11 18.14	10.7	2010 01 13.09	9.7	GON05/ 4
2009 12 18.20	10.6			KUT
2009 12 11.17	11.6			LAB02
2009 12 26.23	10.5	2009 12 29.21	10.3	MEY / 2
2009 11 19.80	11.8			NAG04
2009 12 27.17	10.4			PAR03
2009 12 27.08	10.5			PIL01
2009 11 15.69	11.4	2009 12 23.69	11.6	WYA / 8
2009 11 19.78	11.7			YOS02

Comet 88P/Howell

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 11 02.95	9.0	2009 12 06.96	8.9	AMO01/ 2
2009 09 30.92	8.9	2009 11 05.94	9.0	DES01/ 19
2009 11 18.78	8.4	2009 12 04.78	8.6	GON05/ 2
2009 11 16.75	9.5	2010 01 11.77	10.5	LAB02/ 3
2009 08 14.44	10.4	2009 11 19.46	9.4	MAT08/ 6
2009 12 08.39	10.9			NAG04
2009 11 02.93	8.8:			SOU01
2009 10 31.39	8.4	2009 12 20.43	10.6	WYA / 16
2009 11 14.40	9.4			YOS02

Comet 116P/Wild

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 03 28.50	13.0			MAT08
2009 02 28.83	12.5	2009 03 14.85	12.6	SAN07/ 2

Comet 118P/Shoemaker-Levy

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 11 18.19	13.5	2010 01 12.90	11.5	GON05/ 3
2009 12 14.87	12.4	2009 12 18.01	12.7	KUT / 2
2010 01 11.81	12.1			LAB02
2009 11 19.92	13.3			LEH
2009 12 15.50	12.7	2009 12 16.50	12.7	SEA / 2
2009 12 15.46	12.4	2009 12 23.68	12.7	WYA / 5

Comet 144P/Kushida

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2008 12 31.79	10.4	2009 03 28.76	11.6	CHR / 8
2008 12 30.94	10.2			FIL04
2009 01 20.76	9.4			KER01
2009 01 13.47	8.9	2009 03 28.46	11.0	MAT08/ 5
2009 01 20.71	8.9	2009 04 25.86	12.0:	SAN07/ 5
2009 01 02.81	10.8:			SCI
2009 01 16.81	9.1			TOT03
2009 02 15.78	9.2	2009 03 14.81	11.0	VAS06/ 2

Comet 169P/NEAT

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 11 19.46	[11 :			MAT08
2009 11 21.41	11.6	2009 12 17.43	13.3	WYA / 3

Comet 217P/LINEAR

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 11 27.08	11.8			FIL04
2009 11 18.08	10.7	2010 01 12.92	12.7	GON05/ 4
2009 12 14.89	12.9			KUT
2009 11 15.19	10.7	2010 01 11.80	13.1	LAB02/ 3
2009 11 19.94	11.0			LEH
2009 10 11.67	11.0			MAT08
2009 11 19.67	12.2			NAG04
2009 11 14.17	10.6	2009 12 16.89	11.9	PIL01/ 2
2009 09 26.00	10.5			SAN07
2009 08 22.02	10.3	2009 09 01.08	10.1	SZA / 2
2009 11 18.99	11.5			TOT03
2009 10 15.74	10.2			TSU02
2009 10 31.68	11.3	2009 12 23.69	10.7	WYA / 12
2009 11 19.76	11.3			YOS02

Comet 222P/LINEAR

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 09 01.10	12.5			SZA

Comet C/2006 OF2 (Broughton)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 03 01.78	12.5	2009 03 28.80	12.5	CHR / 4
2009 03 28.46	12.4			MAT08
2009 01 03.81	11.0	2009 04 25.85	11.5	SAN07/ 4
2009 05 25.86	12.5			SZA
2009 05 25.86	12.3			TOT03

Comet C/2006 Q1 (McNaught)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 07 16.92	13.5			SZA

Comet P/2006 W1 (Gibbs)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 02 19.74	10.5			SAN07
2009 05 24.00	9.2			SAR02
2009 06 18.94	9.3			SZA

Comet C/2006 W3 (Christensen)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 07 24.92	9.0	2009 09 20.77	10.2	CHR / 11
2009 07 21.00	8.6	2009 08 20.93	8.6	CSU / 5
2009 07 20.89	9.2:	2009 08 21.92	8.6	FIL04/ 8
2009 11 08.82	9.3	2009 12 04.77	9.4	GON05/ 3
2009 07 16.90	9.3			KUL02
2009 11 16.77	9.5	2009 12 11.76	10.2	LAB02/ 2
2009 07 16.89	9.3	2009 08 23.85	9.5:	LEG / 5

Comet C/2006 W3 (Christensen) [cont.]

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 09 01.81	8.8	2009 11 25.69	10.4	LEH / 7
2009 08 14.54	8.8	2009 11 05.46	9.8	MAT08/ 4
2009 07 12.92	8.5	2009 09 22.84	8.5	SAN07/ 3
2009 07 16.90	8.8	2009 07 20.96	8.8	SAR02/ 2
2009 07 23.83	9.2:	2009 07 30.92	8.8:	SCI / 7
2009 06 18.94	9.3	2009 08 21.83	8.9	SZA / 3
2009 08 24.85	9.5	2009 09 22.87	10.1	TOT03/ 2
2009 06 26.94	8.3	2009 09 21.78	8.4	VAS06/ 7
2009 10 31.40	9.3	2009 11 21.43	9.4	WYA / 11

Comet C/2007 N3 (Lulin)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2008 08 05.81	11.5	2009 04 26.80	11.8	CHR / 17
2009 02 19.15	6.1	2009 03 21.77	7.8	CSU / 6
2009 02 28.77	5.8			DOM
2008 07 01.97	11.1	2009 03 21.92	9.5	FIL04/ 5
2009 01 09.18	7.4			KER01
2009 02 06.15	6.2			KES01
2009 02 28.82	5.7	2009 03 04.93	6.8	KIS03/ 4
2009 03 01.03	6.4	2009 03 14.88	7.7	KWI / 4
2009 02 28.78	6.1:	2009 03 18.83	7.8:	LEG / 4
2009 03 01.04	5.3	2009 03 17.81	7.8	MAR12/ 5
2009 01 24.71	6.7	2009 03 23.42	7.8	MAT08/ 13
2009 02 28.80	5.4			MOS01
2009 02 28.86	5.7	2009 03 13.79	7.4	POW01/ 4
2009 03 01.88	6.0:			SAD
2009 01 09.19	7.3	2009 04 25.85	9.9	SAN07/ 11
2009 02 28.89	6.0	2009 03 04.83	6.8	SCI / 4
2009 03 01.84	6.3			SIE01
2009 02 28.80	6.8	2009 03 01.81	6.5	SIK01/ 2
2009 02 28.91	6.2:			SMY
2009 01 12.19	7.6:	2009 03 21.78	7.9	SWI / 4
2009 03 01.82	5.8			SWI01
2009 02 25.83	5.1	2009 04 12.81	11.1	SZA / 2
2009 03 17.85	7.6			TOT03
2009 02 21.97	5.2	2009 02 28.84	5.4	UJV / 3
2009 02 19.19	5.9	2009 03 24.81	8.4	VAS06/ 6

Comet C/2007 Q3 (Siding Spring)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 11 21.47	10.0			AGU01
2009 12 24.15	10.1	2009 12 26.25	10.1	DIE02/ 2
2009 11 18.17	9.2	2010 01 13.10	9.5	GON05/ 5
2009 10 29.19	10.4			HAS02
2009 11 15.20	9.4	2009 12 11.16	9.8	LAB02/ 2
2009 01 24.52	11.9	2009 03 28.47	11.5	MAT08/ 3
2009 12 21.19	9.7	2009 12 29.20	9.6	MEY / 3
2009 11 19.82	11.7			NAG04
2009 12 27.19	9.8			PAR03
2009 11 14.18	10.3	2009 12 27.09	10.2	PIL01/ 2
2009 12 26.08	10.5			VAS06
2009 12 16.71	11.3	2009 12 23.71	10.8	WYA / 3
2009 11 19.81	10.6			YOS02

Comet C/2008 Q3 (Garradd)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 04 21.54	9.6	2009 08 14.43	10.3	MAT08/ 11
2009 07 19.86	9.2			SZA

Comet C/2008 T2 (Cardinal)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 03 21.78	11.4	2009 04 26.78	11.2	CHR / 9
2009 06 14.37	8.9	2009 08 14.42	[11 :	MAT08/ 2
2009 03 14.80	11.0:	2009 04 25.83	9.8	SAN07/ 3
2009 04 11.82	12.2			SZA
2009 04 20.83	9.7			VAS06

Comet C/2009 E1 (Itagaki)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 03 16.76	9.8			KER01
2009 03 17.42	10.0			MAT08
2009 03 18.76	9.0			SAN07
2009 05 24.03	11.0			SAR02
2009 03 17.79	8.5	2009 03 17.80	9.2	SZA / 2
2009 03 21.78	9.0			TOT03

Comet C/2009 F6 (Yi-SWAN)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 04 19.78	9.6	2009 05 14.81	10.7	CHR / 4
2009 04 11.83	8.9	2009 04 26.88	9.6	FIL04/ 3
2009 04 22.85	8.9			PAR03
2009 04 25.80	10.9			SAN07
2009 04 27.97	8.4:			SCI
2009 04 07.79	9.4	2009 04 12.83	9.9	SZA / 3
2009 04 10.82	10.8			TOT03
2009 04 20.80	9.2			VAS06

Comet C/2009 G1 (STEREO)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 05 05.80	9.3	2009 06 14.38	9.5	MAT08/ 2

Comet P/2009 L2 (Yang-Gao)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 07 20.90	[13.7			SAR02
2009 07 16.88	13.3			TOT03

Comet P/2009 Q4 (Boattini)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 11 18.15	13.3	2009 12 12.08	11.8	GON05/ 3

Comet P/2009 T2 (La Sagra)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 12 04.79	14.8			GON05

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Corrigendum. In the October 2009 issue of the *ICQ*, page 138, first line of text, *for* 15 comets *read* 42 comets

Tabulated CCD-Data Summary

The tabulation below lists, for each comet, the first and last observation, with associated CCD magnitude measurement and "passband" (the one-letter code following the magnitude being the "magnitude method", which for CCDs has `C` = unfiltered CCD, `k` = Cousins *R*-band, etc.) for each observer, listed in alphabetical order of the observers within each comet's listing (the usual 3-letter, 2-digit observer code coming under the column `Obs.`, whose key is provided above). The final column (separated by a slash, /, from the observer code) provides the number of individual 129-character observation records entered into the *ICQ* archive from that observer for the particular comet for this issue; when only one observation was submitted by a specific observer for a given comet, the last column is left blank (with no slash mark after the observer code). The complete observations in their 129-column form are posted at the *ICQ* website and can be obtained directly by request from the *ICQ* Editor. See the remarks on pages 96 and 105 of the July 2007 issue, and page 34 of this issue, for additional information on this new summary tabulation.

Comet 14P/Wolf

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 09 24.71	[19.6 C	2009 11 14.60	19.3:C	TSU02/ 3

Comet 22P/Kopff

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 09 24.51	12.4 C	2009 11 14.50	14.6 C	TSU02/ 5
2009 10 12.51	11.3 H	2009 11 19.49	13.4 H	YOS02/ 6
2009 11 21.43	14.2 C	2009 11 23.40	14.5 C	YUS / 2

Comet 30P/Reinmuth

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 11 14.73	16.9 C			TSU02

Comet 43P/Wolf-Harrington

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 12 04.41	17.3 C			YUS

Comet 47P/Ashbrook-Jackson

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2010 01 02.88	17.9 C	2010 01 02.88	18.4 C	HAE / 3

Comet 88P/Howell

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 10 21.40	10.1 C			TSU02
2009 12 01.38	11.1 C			YUS

Comet 107P/Wilson-Harrington

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 11 06.41	17.6 C	2009 11 14.48	17.0 C	TSU02/ 3
2009 11 07.40	16.7 C	2009 12 14.45	17.3 L	YOS02/ 12
2009 12 01.42	16.9 C			YUS

Comet 118P/Shoemaker-Levy

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 09 24.80	16.0 C	2009 11 14.65	13.8 C	TSU02/ 2

Comet 157P/Tritton

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 11 21.82	17.3 V			QVA
2009 09 24.59	17.7 C	2009 11 14.56	17.5 C	TSU02/ 4
2009 11 19.51	17.0 C			YOS02
2009 12 04.44	16.1 C			YUS

Comet 169P/NEAT

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 11 21.38	16.7 C			YUS

Comet 217P/2009 F3 (LINEAR)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 12 12.99	12.0 C	2009 12 12.99	14.3 L	QVA / 3
2009 09 24.75	11.4 C	2009 11 14.67	12.1 C	TSU02/ 2
2009 11 19.60	12.0 V	2009 11 19.61	11.0 H	YOS02/ 3

Comet 219P/2009 H1 (LINEAR)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 12 04.39	17.1 C			YUS

Comet 224P/2009 Q2 (LINEAR-NEAT)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 09 24.63	[20.3 C			TSU02

Comet 226P/2009 R2 (Pigott-LINEAR-Kowalski)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 09 24.81	18.1 C			TSU02

Comet 232P/2009 W1 (Hill)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2010 01 05.20	16.8 C	2010 01 13.16	17.8 C	HAE / 11

Comet C/2006 S3 (LONEOS)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 12 01.49	17.4 C			YUS

Comet C/2006 W3 (Christensen)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 09 07.51	11.7 C	2009 10 21.41	10.3 C	TSU02/ 2
2009 11 21.41	10.7 C			YUS

Comet C/2007 Q3 (Siding Spring)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 11 24.25	11.9 V	2009 11 24.25	12.7 L	QVA / 2

Comet C/2007 VO_53 (Spacewatch)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 11 07.55	16.9 C			YOS02

Comet C/2008 N1 (Holmes)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 09 07.45	16.9 C			TSU02

Comet C/2008 P1 (Garradd)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2010 01 02.71	17.3 C	2010 01 04.72	17.5 C	HAE / 9
2009 09 24.53	16.4 C	2009 10 21.50	16.7 C	TSU02/ 2
2009 10 12.57	15.9 C			YOS02

Comet C/2009 O4 (Hill)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 10 12.54	15.0 C			YOS02

Comet P/2009 Q4 (Boattini)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 11 14.72	13.4 C			TSU02

Comet P/2009 Q5 (McNaught)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 09 24.67	17.5 C	2009 11 14.57	16.8 C	TSU02/ 2
2009 11 19.54	16.9 C			YOS02

Comet C/2009 R1 (McNaught)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 10 12.47	16.9 C			YOS02

Comet P/2009 T2 (La Sagra)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2009 12 01.52	16.3 C			YUS

Comet C/2009 U3 (Hill)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2010 01 02.82	15.8 C	2010 01 02.82	18.0 C	HAE / 6

Comet P/2010 A1 (Hill)

First Date UT	Mag.	Last Date UT	Mag.	Obs. / No.
2010 01 13.13	16.4 C	2010 01 13.13	18.6 C	HAE / 6

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DESIGNATIONS OF RECENT COMETS

Listed below, for handy reference, are the last 45 comets (non-spacecraft) to have been given designations. A comet's name is preceded by a star (⋆) if the comet was a new discovery (compared to a recovery from predictions of a previously-known short-period comet) or a # if a re-discovery of a 'lost' comet. Also tabulated below are such values as the orbital period (in years) for periodic comets, date of perihelion, T (month/date/year), and the perihelion distance (q, in AU). Four-digit numbers in the last column indicate the *IAU Circular* (4-digit number) containing the discovery/recovery or permanent-number announcement. [Update of list in the April 2009 issue, p. 80].

	New-Style Designation	P	T	q	*IAUC*
⋆	C/2009 U1 (Garradd)		5/16/09	6.05	9085
	228P/2009 U2 (LINEAR)	8.51	8/23/11	3.43	9085
⋆	C/2009 U3 (Hill)		3/20/10	1.41	9086
⋆	P/2009 U4 (McNaught)	11.4	9/9/09	1.65	9087
⋆	C/2009 U5 (Grauer)		6/22/10	6.09	9088
⋆	230P/2009 U6 (LINEAR)	6.27	8/8/09	1.49	9090
⋆	232P/2009 W1 (Hill)	9.49	10/1/09	2.98	9095
⋆	C/2009 W2 (Boattini)		5/1/10	6.91	9096
	231P/2009 X1 (LINEAR-NEAT)	8.08	5/16/11	3.03	9101
⋆	C/2009 Y1 (Catalina)		1/28/11	2.52	9102
⋆	P/2009 Y2 (Kowalski)	16.6	3/30/10	2.34	9103
⋆	P/2010 A1 (Hill)	9.15	8/6/09	1.95	9104
⋆	P/2010 A2 (LINEAR)	3.47	12/4/09	2.01	9105
⋆	P/2010 A3 (Hill)	14.9	4/3/10	1.62	9106
⋆	C/2010 A4 (Siding Spring)		10/8/10	2.74	9107
⋆	P/2010 A5 (LINEAR)	11.5	4/19/10	1.71	9108
⋆	C/2010 B1 (Cardinal)		2/7/11	2.94	9113
⋆	P/2010 B2 (WISE)	5.49	12/21/09	1.61	9115
⋆	P/2010 C1 (Scotti)	18.8	12/1/09	5.24	9116
⋆	233P/2009 WJ$_{50}$ (La Sagra)	5.29	3/12/10	1.79	9117
⋆	P/2010 D1 (WISE)	8.45	6/25/09	2.67	9118
⋆	P/2010 D2 (WISE)	17.3	3/5/10	3.66	9121
⋆	C/2010 D3 (WISE)		9/3/10	4.25	9122
⋆	C/2010 DG$_{56}$ (WISE)		5/15/10	1.59	9123
⋆	C/2010 E1 (Garradd)		11/7/09	2.66	9124
⋆	C/2010 D4 (WISE)		3/30/09	7.15	9125
⋆	P/2010 E2 (Jarnac)	25.4	4/7/10	2.40	9125
⋆	C/2010 E3 (WISE)		4/4/10	2.27	9126
⋆	234P/2010 E4 (LINEAR)	7.47	12/23/09	2.86	9126
⋆	C/2010 E5 (Scotti)	123	11/21/09	3.89	9127
⋆	C/2010 F1 (Boattini)		11/10/09	3.59	9128
⋆	P/2001 Q11 (NEAT)	6.18	6/22/01	1.85	9129
⋆	235P/2010 F2 (LINEAR)	8.01	3/21/10	2.75	9130
⋆	C/2010 F3 (Scotti)		8/4/10	5.45	9131
⋆	C/2010 F4 (Machholz)		4/6/10	0.61	9132
⋆	C/2010 G1 (Boattini)		4/2/10	1.20	9133
⋆	C/2010 G2 (Hill)		9/2/11	1.98	9134
⋆	P/2009 WX$_{51}$ (Catalina)	5.41	1/31/10	0.80	9135
⋆	C/2010 G3 (WISE)		4/11/10	4.91	9136
⋆	C/2010 H1 (Garradd)		6/18/10	2.75	9136
⋆	P/2010 H2 (Vales)	7.56	3/9/10	3.11	9137
⋆	P/2010 H4 (Scotti)	17.0	6/19/10	4.83	9139
⋆	C/2010 FB$_{87}$ (WISE-Garradd)		11/7/10	2.84	9141
⋆	C/2009 UG$_{89}$ (Lemmon)		12/16/10	3.93	9141
⋆	C/2010 J1 (Boattini)		2/4/10	1.70	9143