At the end of the Hazards meeting, we had a tour of Spacewatch on Kitt Peak. Driving back several of us sang Russian folk songs. Brian joined right in. Even the Russian scientists joined in.

These are just some of my memories. Thank you for letting me share them with you. Thank you, Brian for being a part of my life.

Φ Φ Φ

Comet 12P/Pons-Brooks: Identification with Comets C/1385 U1 and C/1457 A1

Maik Meyer (Limburg, Germany)
Takao Kobayashi (Oizumi, Gunma-ken, Japan)
Syuichi Nakano (Sumoto, Japan)
Daniel W. E. Green (Harvard University)

Abstract. Comet 12P/Pons-Brooks is an intermediate-period comet (orbital period around 71 years) comparable to 1P/Halley. The comet was seen first in 1812, and then again in 1883 and 1954. The comet was recovered in 2020 and will pass perihelion in 2024. We report the unambiguous identification of this comet with the historic comets C/1385 U1 and C/1457 A1; we were able to link both historic apparitions with 12P. The link is also supported by the historic descriptions of its appearance and brightness. Further, we discuss other historical comets for possible relationships with 12P and identify a comet seen in 245 as a probable earliest recorded sighting of 12P/Pons-Brooks.

1. Introduction

Periodic comet 12P/Pons-Brooks was discovered by J. L. Pons on 1812 July 21 from Marseille, France; the comet was followed during that apparition until September 28. It was re-discovered by W. R. Brooks on 1883 September 2 from Phelps, NY, USA, and followed until 1884 June 2; during that apparition, the comet experienced several outbursts. At its next apparition, in 1954, comet 12P also exhibited several outbursts. Condensed observational details of all three apparitions can be found in Kronk (2003, 2009).

Despite the fairly high absolute magnitude of around 4-5 and the comet's apparent tendency to have occasional outbursts, it seems that no searches for earlier appearances have been made using historical data. In February 2020, the first author integrated the orbit of 12P backward until about the year 1000. The calculations used data from the apparitions of 1883-1884 and 1953-1954 (taken from the Minor Planet Center's online database). From the integration backwards, it was apparent that the orbit for this comet is very stable and does not experience strong planetary gravitational perturbations in the covered period. From a check of different cometographies, it was apparent that the first comet of 1457 and the comet of 1385 were almost perfect matches concerning the perihelion time. As a next step, these backward-integrated orbits were compared with catalogued orbits for the 1385 and 1457 comets, using a planetarium software program ("GUIDE", by B. Gray; cf. website URL `https://www.projectpluto.com`) that showed that the integrated orbits for 12P were fully compatible with the observed paths and the observational circumstances of the 1457 and 1385 comets. Not only did 12P appear positioned within the area indicated by the ancient observations but also the sense of movement did fit perfectly. By adjusting the perihelion time by a few days for each of these apparitions, the match could be brought even closer.

2. The Comet of 1457

In 1864 a manuscript by Italian cartographer and astronomer P. Toscanelli was found in the National Library in Florence, Italy. The manuscripts contained observations of six comets seen by Toscanelli in the 15th century, with their positions drawn into celestial maps drawn by Toscanelli. After the discovery of the manuscripts, G. Celoria performed in-depth investigations of Toscanelli's manuscripts and derived orbits from the positions drawn by Toscanelli. The first comet of 1457 was observed daily on five nights between 1457 January 23 and 27. Celoria published his analyses, including the derived orbits, several times (Celoria 1884, 1894, 1921). His orbit is based on three of the five observations and via comparison with the other two observations. He correctly states that the orbit is not of much accuracy due to the very short arc.

The Toscanelli drawings show a short tail extending to about 0.5 degrees. There are indications of a coordinate grid in Toscanelli's drawings that at times seems incomplete, but it helped Celoria to identify the area of the sky where the comet was seen. A more contemprorary analysis of Toscanelli's maps can be found in Jervis (1985). Figures 1 and 2 show the original drawing by Toscanelli and the representation by Celoria, respectively. It can be seen from the images that

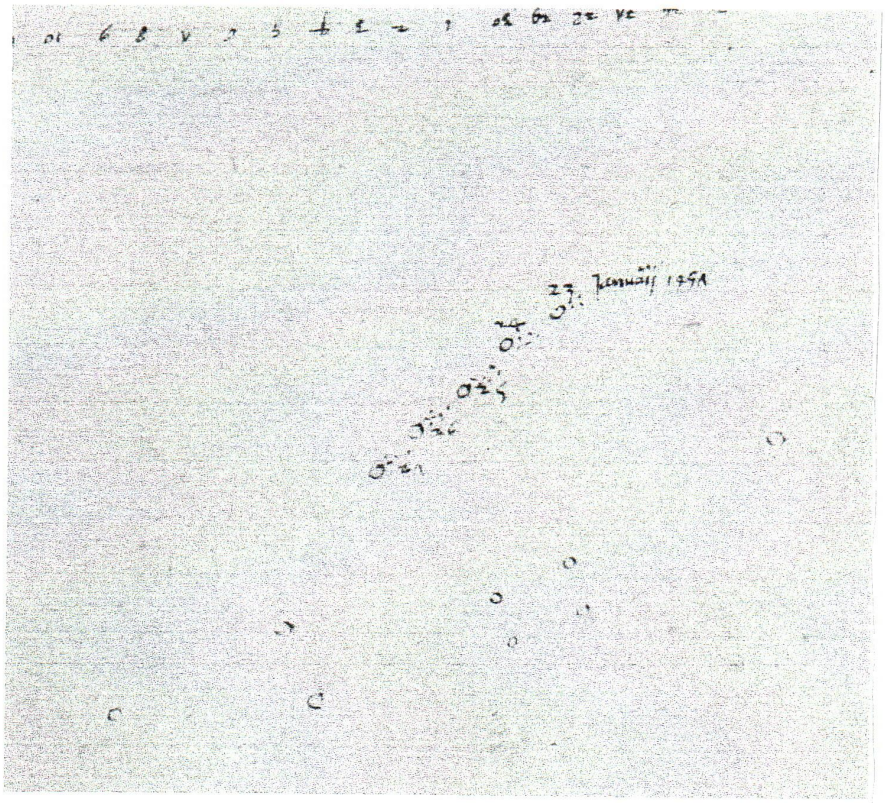


Figure 1: Drawing of the positions of the comet of January 1457 by P. Toscanelli. Image courtesy F. Stoppa, Milan, Italy.

◇ ◇ ◇

the accuracy can only be good to maybe a few degrees, and any orbit derived from them is prone to some considerable uncertainty, something that Celoria (1894) acknowledged quite clearly: "The observations, despite their nature, are quite well represented from my orbital elements, but they, even if of a remarkable precision for that time, are too close to each other and too few to judge with certainty how much the orbital elements themselves are close to the real ones."

But Toscanelli was apparently not the only observer of this comet. There exists a Chinese observation of the 1457 comet that, however, bears a problem. The Chinese reports are as follows (Pankenier, Xu, and Jiang 2008) and are given for 1457 January 14: "7th year of the Jingtai reign period of Emperor Yingzong of the Ming Dynasty, 12th month, day jiayin [51], at night, a broom star with bright rays 5 cun long reappeared in lunar mansion BI [LM 19], slowly traveling southeastward. Its bright rays gradually lengthened from this day through day guihai [60]. [Ming Yingzong shilu] ch. 273". Another Chinese source given there (Ming shi: tianwen zhi, ch. 27) supplies basically the same information.

Stryuck (1740, p. 247) wrote: "Besides the story about the Comet one finds in the last mentioned Chronicle [*Anton. de Ripalta Annal. Placent.*, col. 905] that in the Year 1456, in the Month of December, and in the Year 1457, in January, four strange Stars appeared, moving from the East to the West, almost in the shape of a Cross. This could easily be some Fixed Stars or one or more Planets." *Ludov. Cavitel. Cremonen. Annal.* (col. 1456, tom. 3, par. 2) tells about a "Comet that was seen in the Year 1456, the 5th of December, and another one in January ..." Interestingly, both Struyck and Lubienietz (1667) mention the comets of June 1456 and June 1457, but nothing more on the comet of Jan. 1457 (other than that above). And neither of these two cometographers mentioned the 1385 comet at all; as they both had access to many European historical materials on comets, it says a lot that these comets were not apparently widely known in Europe, so they must not have been very bright and thus not easily seen from Europe.

What can be deduced from the Chinese texts? First, the object was seen as early as 1457 January 14 – but possibly earlier, since the word 're-appeared' is used. Second, the tail was about 0.5 degrees long; 1 *cun* is about 0.1 degrees. This nicely agrees with the length derived by Celoria from Toscanelli's drawings. Third, the object was seen for about 10 days, until January 23.

The main problem with the Chinese observation (which was also discussed at length by Celoria) is the position in the lunar mansion *Bi* (or *Pi*), which corresponds to lunar mansion 19 and refers to the area around the Hyades and ϵ Tau, also called the "Hunting Net". However, using the orbital elements of 12P, the comet would have been near ω Psc and γ Peg on that date. It can be concluded that the Chinese position is not at all compatible with the Toscanelli observations, except there is an error in the Chinese sources (see also the similar remark by Celoria). For the Chinese

comet, 12P would have been in the 14th lunar mansion, called *Dongbi* or *Tung-bi* but sometimes also given as *Pi* (Ho 1962). If the 14th and 19th lunar mansions were mixed up, then 12P would be correctly placed on 1457 January 14; but, of course, this cannot be proven anymore.

Finally, another argument for the identity with 12P: Based on the derived magnitude parameters of the apparition of 1953, the magnitude of 12P in 1457 was perhaps at mag 3-4 (assuming no outburst), with the comet being close to perihelion and about 0.95 AU from the earth. This would explain why it was not such a conspicuous object. If Celoria's orbit were correct, the comet would have brightened further with increasing elongation in the following days which raises the question why it was not observed further by Toscanelli. The orbit of comet 12P shows that it in fact became fainter with a slowly increasing elongation, which explains the short observation period.

As a sidenote, it should be mentioned that the 1457 comet was long suspected to be identical with what later became known as comet 27P/Crommelin (Schulhof 1885; Galle 1894, p. 157; Procter and Crommelin 1937). Modern calculations were not able to confirm this and, moreover, that identity can be ruled out (Marsden 1975; Festou, Morando, and Rocher 1985).

The orbital elements by Celoria are given here for reference: $q = 0.703$ AU, $\omega = 195°$, $\Omega = 258°$, $i = 13°$.

◇ ◇ ◇

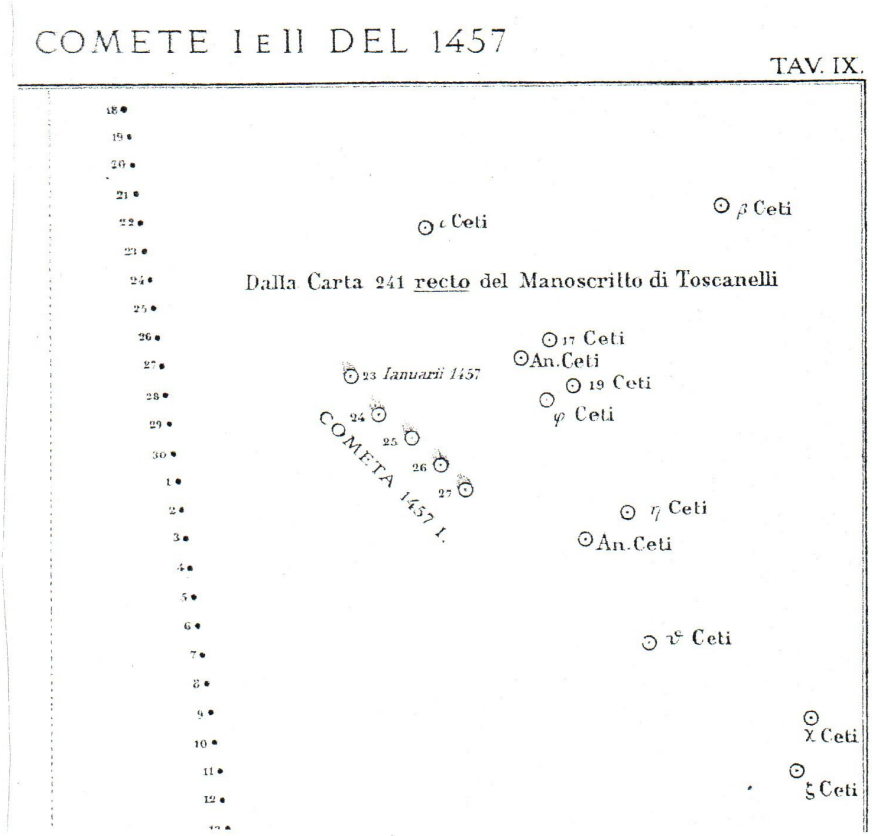


Figure 2: Representation of Toscanelli's drawing by G. Celoria (1894). Image courtesy F. Stoppa, Milan, Italy.

◇ ◇ ◇

3. The Comet of 1385

For the 1385 apparition, we only have the description of the comet's apparent movement from Asian sources: the *Ming Taizu shilu*, ch. 175, and *Ming shi: tianwen zhi*, ch. 27 (Pankenier et al. 2008). On 1385 October 23, the comet appeared near Coma Berenices, Leo, and Virgo, and after that, moved towards β Vir and left the area of β and η Vir. On 1385 October 30, the comet entered Crater; on November 4 it "trespassed against" an asterism in Hydra. The comet had a 10° tail according to Biot (1843a; see also Carl 1864, p. 42). The widely cited orbit by Hasegawa (1979) of course resembles this general movement.

The orbit of 12P is perfectly consistent with the above description and moves similarly to comet C/1385 U1; the apparent path in the sky fits the description from the Chinese records even better. Using the magnitude parameters from the 1953 apparition, the brightness was perhaps around magnitude 2 (assuming no outburst), since the apparition

was very favorable due to a close approach to the earth. This agrees well with the Chinese observations, too.

Several orbits have been calculated from the Chinese descriptions in the past, including the following (given here for equinox J2000.0): Peirce (1846): $q = 0.755$ AU, $\omega = 155°$, $\Omega = 270°$, $i = 105°$; Hind (1846): $q = 0.738$ AU, $\omega = 130°$, $\Omega = 296°$, $i = 52°$; Hasegawa: $q = 0.79$ AU, $\omega = 289°$, $\Omega = 103°$, $i = 103°$.

As noted above for the 1457 comet, neither Struyck nor Lubienietz mentioned the 1385 comet at all; since they both had access to many European historical materials on comets, it says a lot that these comets were not apparently widely known in Europe, so they must not have been very bright and thus not easily seen from Europe.

Nevertheless, the comet was not completely missed in Europe. J. Meyerus Baliolanus (1561) gives an account of a comet seen on the feast day of Saints Cosmas and Damian, which corresponds to September 27, 1385, when the comet would have been at magnitude 5, but it may have been in outburst then. However, his text also says that the comet appeared in October. He goes on to say that the comet did shine in many colors. A similar account can be found in a later annal by E. Sueyro (1624), with the only difference being that he put it in the year 1386; from the description, it could also relate to an aurora. Another mention can be found in the annals the German city of Trier (1838); the editors of this edition remark on a manuscript that states that in 1385 a terrible comet appeared. The comet can also be found in annals of Iceland (1847), which simply says for 1385 that a comet appeared.

4. Linkage

For the linkage of the apparitions of 1385 and 1457, the following positions were derived from the descriptions in the historical sources.

1385 UT	R.A. (2000)	Decl.	Mag.
Oct. 22.9	12 00	+12 00	2
29.9	11 55	- 8 00	
Nov. 3.9	11 55	-35 00	

1457 UT	R.A. (2000)	Decl.	Mag.	Observer
Jan. 23.7	0 40	- 3 40	3	Toscanelli
25.7	0 47	- 5 20		"
27.7	0 56	- 7 15		"

The observations of the apparitions of 1812 and 1883-1884 were re-reduced recently by co-author T. Kobayashi, from which a linked orbit could be derived and which was published by Green (2020a) and Nakano (2020a). These re-reduced astrometric observations are posted at the *ICQ* website (Kobayashi 2021).

Prompted by these announcements, the comet was recovered on 2020 June 10 and 17 with the Lowell Observatory 4.3-m Discovery Telescope and the Large Monolithic Imager by Ye et al. (2020a) with the comet at a distance of 11.9 AU. On stacked images, a broad tail of 3′ length was visible, implying that it was already active. The correction to the orbit by Kobayashi based on the data from 1385-1954 was only +0.16 day (see Green 2020b). While including these recovery observations, the linked orbital presented in Table 1 were derived. His elements are based on a total of 1052 astrometric observations and include perturbations by Mercury-Neptune and Ceres, Pallas, and Vesta. Non-gravitational effects were included in the orbit computation. The weighted mean residual is 1″.41. The comet passed 3.71 AU from Uranus on 1819 Apr. 26 and 1.62 AU from Saturn on 1957 July 29 UT. The comet has made numerous close approaches to the earth (0.41 AU on 1385 Oct. 29, 0.90 AU on 1457 Jan. 10, and 0.63 AU on 1884 Jan. 9 UT).

It should be noted that a correction in (ET-UT) for the 1385 and 1457 observations was ignored since no definitive values for (ET-UT) are available. However, following Stephenson (1997) and using approximate values for (ET - UT) of +330 s for 1385 and +220 s for 1457, the residuals amount to about 48″ and 12″, and perihelion time corrections of only about −0.002 and +0.005 day, respectively.

Figures 3 and 4 show the apparent paths for both apparitions based on Celoria's and Hasegawa's orbits, respectively. They also show the paths based on the linked orbit by Kobayashi. It can be seen that the apparent paths from the linked orbit by Kobayashi are quite similar to the apparent paths from orbits by both Celoria and Hasegwawa.

5. Discussion of sightings at other apparitions

On the basis of the orbits given in Table 2 below, a search was conducted in historical comet reports for other sightings of comet 12P/Pons-Brooks. It is reasonable to assume that non-gravitational forces, which are also present for this comet, should not change the predicted orbits before 1385 by a large amount, since this would require a substantial change in these forces that were quite constant between 1385 and now.

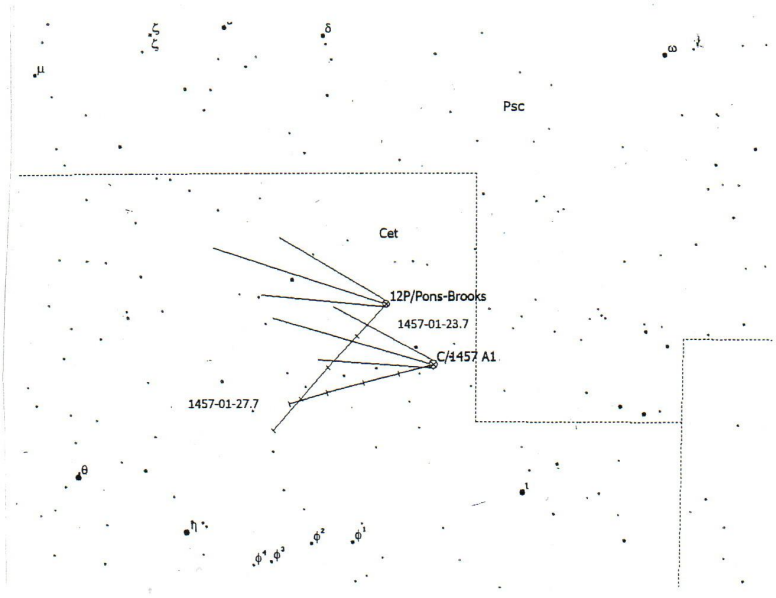
It should be stressed that for a comet to be noticed by chance without a telescope, it needs to be placed in dark skies at solar elongations > 40-50 degrees, and at a certain brightness (say, brighter than visual magnitude 3-4 in a moonless sky). For most of the apparitions discussed in the text below, this is not the case. The apparitions of 1457 and 1385 were very favorable, where the comet was close to the earth and bright enough to be easily seen. From the orbital circumstances, a perihelion occurring between August and January provides the most favorable viewing conditions. However, one has to take into account that 12P is prone to outbursts. This is why it seems nevertheless useful to look at each apparition and see whether other historic candidates are available.

TABLE 1. NEW ORBITAL ELEMENTS FOR COMET 12P/PONS-BROOKS

```
                Epoch = 1385 Nov.  8.0 TT
T = 1385 Nov.  6.327 TT          Peri. = 200.036
e = 0.95505                      Node  = 255.125   2000.0
q = 0.78362 AU                   Incl. =  73.829
  a = 17.431967 AU     n = 0.013542     P =  72.78 years

                Epoch = 1457 Jan. 14.0 TT
T = 1457 Jan. 30.1002 TT         Peri. = 199.9041
e = 0.954800                     Node  = 255.2502  2000.0
q = 0.778438 AU                  Incl. =  74.0399
  a = 17.22216 AU    n = 0.0137903    P =  71.47 years

                Epoch = 1812 Aug. 30.0 TT
T = 1812 Sep. 15.82612 TT        Peri. = 199.29022
e = 0.9553274                    Node  = 255.63879 2000.0
q = 0.7771051 AU                 Incl. =  73.95643
  a = 17.3955643 AU   n = 0.01358458   P =  72.55 years

                Epoch = 1884 Jan. 25.0 TT
T = 1884 Jan. 26.21681 TT        Peri. = 199.17679
e = 0.9550368                    Node  = 255.77454 2000.0
q = 0.7757320 AU                 Incl. =  74.04048
  a = 17.2526163 AU   n = 0.01375377   P =  71.66 years

                Epoch = 1954 May  18.0 TT
T = 1954 May  22.88058 TT        Peri. = 199.02746
e = 0.9548317                    Node  = 255.89097 2000.0
q = 0.7736564 AU                 Incl. =  74.17689
  a = 17.1283021 AU   n = 0.01390377   P =  70.89 years

                Epoch = 2024 May  10.0 TT
T = 2024 Apr. 20.99698 TT        Peri. = 198.98718
e = 0.9545914                    Node  = 255.85595 2000.0
q = 0.7807641 AU                 Incl. =  74.19138
  a = 17.1941867 AU   n = 0.01382393   P =  71.30 years
```

◇ ◇ ◇

Figure 3: Comparison of the paths of comet C/1457 A1 based on Celoria's orbit and comet 12P/Pons-Brooks based on the linked orbit.



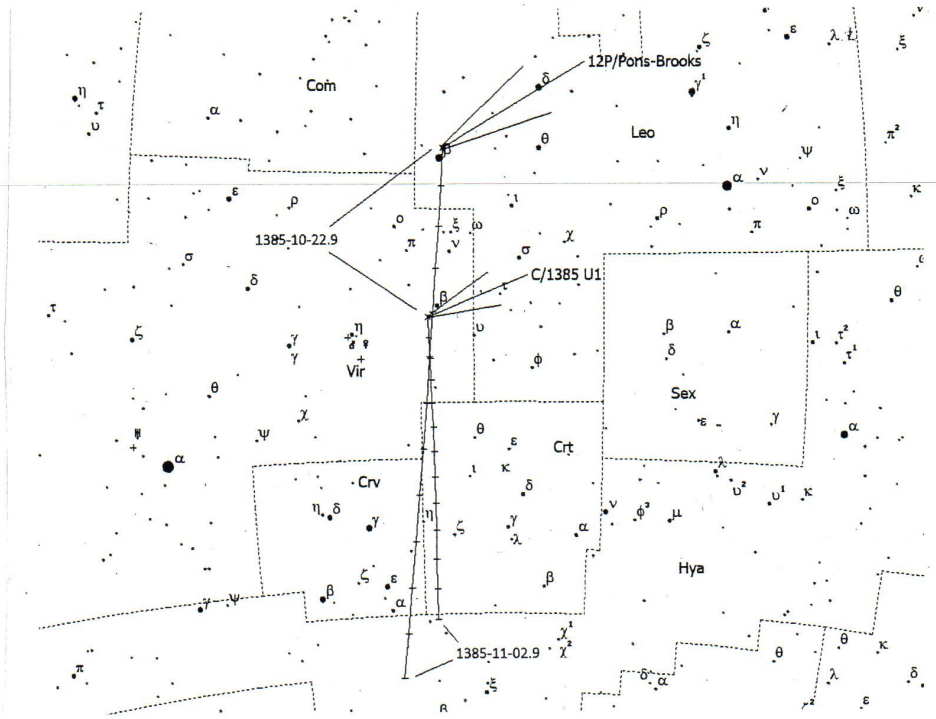


Figure 4: Comparison of the paths of comet C/1385 U1 based on Hasegawa's orbit and comet 12P/Pons-Brooks based on the linked orbit.

◇ ◇ ◇

Table 2: Orbital elements by T. Kobayashi for 12P/Pons-Brooks, based on observations from 1385-2020.

	T	q	e	Peri.	Node	i	Epoch
0012	33 03 24.392	0.783058	0.955528	201.801	253.835	73.443	330331
0012	105 08 27.621	0.777178	0.955319	201.719	253.956	73.656	1050820
0012	176 05 17.343	0.774058	0.954814	201.597	254.078	73.899	1760519
0012	245 09 15.466	0.772882	0.954562	201.409	254.157	74.028	2450914
0012	315 03 12.893	0.785689	0.954230	201.456	254.037	73.992	3150331
0012	386 09 08.388	0.787368	0.954884	201.372	254.025	73.741	3860825
0012	459 07 16.245	0.787975	0.955172	201.303	254.095	73.647	4590802
0012	532 06 28.502	0.783021	0.955135	201.252	254.266	73.771	5320709
0012	603 07 03.510	0.777660	0.954684	201.134	254.378	74.057	6030627
0012	673 01 08.923	0.777703	0.954382	200.940	254.435	74.145	6730110
0012	742 10 28.225	0.779050	0.954594	200.797	254.473	74.053	7421015
0012	813 08 06.236	0.780271	0.955070	200.671	254.407	73.909	8130823
0012	886 04 02.499	0.782316	0.955414	200.607	254.504	73.748	8860402
0012	959 01 24.841	0.777944	0.955474	200.548	254.627	73.733	9590129
0012	1030 07 12.737	0.772739	0.955157	200.430	254.763	73.951	10300625
0012	1100 06 12.277	0.770363	0.954827	200.273	254.872	74.143	11000617
0012	1170 02 27.511	0.781288	0.954490	200.288	254.843	74.039	11700210
0012	1241 04 11.464	0.783938	0.954852	200.192	254.899	73.886	12410418
0012	1313 05 01.651	0.784435	0.955108	200.093	254.962	73.812	13130510
0012	1385 11 06.327	0.783616	0.955047	200.036	255.125	73.829	13851108
0012	1457 01 30.100	0.778438	0.954800	199.904	255.250	74.040	14570114
0012	1527 03 12.625	0.776586	0.954673	199.720	255.326	74.106	15270328
0012	1597 07 03.752	0.777688	0.954791	199.582	255.410	74.060	15970618
0012	1668 04 17.408	0.777538	0.955174	199.441	255.389	73.979	16680426
0012	1740 07 14.017	0.779445	0.955366	199.371	255.513	73.900	17400628
0012	1812 09 15.826	0.777105	0.955327	199.290	255.639	73.956	18120830
0012	1884 01 26.217	0.775732	0.955037	199.177	255.775	74.040	18840125
0012	1954 05 22.881	0.773656	0.954832	199.027	255.891	74.177	19540518
0012	2024 04 20.997	0.780764	0.954591	198.987	255.856	74.191	20240510

[text continued from page 118]

Below we discuss earlier returns to perihelion that were missed by observers. Returns to perihelion prior 1385 are only discussed if there was a promising candidate identified or the comet experienced a particularly favorable apparition.

Perihelion 1740 July 14

This apparition was not favorable concerning the observing geometry. The comet might have become brighter than magnitude 10 in April, but already at an elongation below 50°. In May the brightness may have attained magnitude 7, but the elongation was then below 40°. Perihelion was reached almost behind the sun, the elongation being then around 16°, the brightness perhaps magnitude 4. The comet then moved quickly southward and remained at elongations below 45°. There is also no promising candidate in any known records to be found.

Perihelion 1668 April 17

This return to perihelion was also not favorable, with the observing geometry being very poor. In January the comet might have been at magnitude 9 at elongations of just below 60°. Perihelion was reached at only 22 degrees elongation with a magnitude of perhaps 4.

There was one comet observed in 1668 from March 3 to 30, which is known as C/1668 E1. Its orbit is in no way compatible with 12P and can clearly be excluded. This was a very bright comet, a sunskirter with a perihelion distance of only 0.066 AU that had a long tail and was brighter than Venus.

There are other records of a comet seen earlier in 1668. In a paper by Park and Chae (2007), a comet is mentioned that was seen by Korean observers from March 11. While Park and Chae attribute this object to 12P, it is more likely that it is another description of C/1668 E1. It would have been strange to see another bright comet in the same general region of the sky, as only one bright known comet was then observed widely throughout the world. And it again has to be stressed that 12P was likely near magnitude 11 on 1668 March 11! It would have taken a very large and long-lived outburst to bring it to a brightness level to be seen with the unaided eye by the Koreans (and then only by the Koreans).

Perihelion 1597 July 3

The year 1597 saw another unfavorable return to perihelion for comet 12P, similar to or even worse than the one of 1740. There is also no candidate record in historic sources.

Perihelion 1527 March 12

In November 1526, the comet might have become brighter than magnitude 10 at an elongation of just below 70°. It continued to perihelion in March 1527, which was reached at an elongation of just above 30° and with a brightness of perhaps magnitude 4. There are historic records of comets in 1523 and 1529, but the descriptions do not fit.

Perihelion 1313 May 1

The next perihelion before 1385 occurred in 1313, and it was again an unfavorable apparition for earth-based viewers (comparable to 1668). The comet remained at low elongations, and perihelion was attained with magnitude perhaps 4 at elongations below 15°.

There was a comet seen on 1313 April 13, about 1.5 months prior to perihelion passage for 12P (when it would have been perhaps at magnitude 5 and at 15° elongation). Park and Chae have suggested this comet as a candidate for 12P, too. Unfortunately, the indicated position in Gemini is not consistent with the position in Aries given by our orbit. So this object can be clearly ruled out.

Pingre (p. 425) gives a description of the same or another object following the Asian account based on the manuscripts of the historian Mussati (1727, p. 554) who lived from 1261-1329: "In Europe, on April 16, Jupiter and Venus were in conjunction in the sign of Gemini. Four days later a comet was seen in Italy towards the place in the sky where the Sun appeared, when it was about to enter the waters of the ocean: its hairy tail, similar to a whitish smoke, extended to the distance of twenty feet on the west side (it should be read, on the east side). After gradually weakening for a fortnight, this Comet finally vanished. Other Historians similarly testify that the Comet was seen from the west side; therefore his tail could not look to the West."

On that date – April 17 – 12P/Pons-Brooks would have been at an elongation of only 13° and visible low above the western horizon in twilight with a magnitude of maybe 4.5. If the comet would have experienced an outburst around that time it might have been visible even under such conditions but the descritption of a long tail seems to contradict a recent outburst. Probably this account also relates to the Asian Gemini object.

Perihelion 1241 April 11

Another unfavorable apparition with the comet becoming brighter than magnitude 6 already at a small elongation of below 35°. Maximum brightness of about magnitude 4.5 was attained at an elongation of 20°. In May the comet had traveled southward and became fainter than magnitude 6 at an elongation of about 45°. The Japanese text *Dai Nihon shi* reports that on February 17, "a broom star was seen" (Pankenier 2008, p. 149). At that time, the comet might have been as bright as magnitude 6.5-7 and at an elongation of 43°. It should have been visible only if there was an outburst.

Perihelion 959 January 24

The 959 return to perihelion of 12P is similar to that of 1457, when Toscanelli saw the comet from Italy. There is one comet in historical records in 959, but the details are very uncertain. They come from a Byzantine text dated 990 and provide no observational details, but rather relate it to the death of Constantine VII Porphyrogenitus (who died on 959 November 9; Kronk 1999). The comet would then be expected to be bright in January. Hasegawa (1980) gives a date of 959 Oct. 17 for this comet and lists another for 959 May, seen from Arabia.

Stryuck (1740, p. 217) wrote: "In the Year 959, a Comet was seen as a dim [literally "sad and dark"] light. (*Constantin. Porphyr. incerti Continuat.*, p. 289 [e.g., cf. Niebuhr 1838]; *Symeon Magist & Logoth. Annal.*, p. 496). When the Comet was seen at the death of the mentioned Emperor, then it must have appeared in the middle of November." Struyck also suggested identify with the 1652 comet: "This was the Comet that was seen in the Year 1652." Chambers (1889, p. 572) cites two sources for a comet in 959, one saying "a gloomy and obscure star" (citing the extension of the *Chronographia* of Theophanes the Confessor by Constantine VII, likely taking his citation directly from Struyck) and the other saying that it appeared from Oct. 17 to Nov. 1 [but a careful reading of the second source, Tackio (1653), doesn't appear to mention either the 959 comet of these specific dates].

Perihelion 886 April 2

This apparition is comparable to that of 1241. The comet was already at an elongation of below 40° when it became brighter than magnitude 6 at the end of February. A maximum magnitude of perhaps 4.5 was attained at an elongation of 22 degrees; it then moves southward and became fainter than magnitude 6 in mid-May at an elongation of ~ 45°. Three Chinese texts mention a comet seen between June 6 and July 5 (Pankenier 2008, p. 102). The *Xin Tang shu: Xizong ji*, the *Xin Tang shu: tianwen zhi*, and the *Jiu Tang shu: Xizong ji* say that a "star became fuzzy" in JI (lunar mansion 7, near γ Sgr) and WEI (lunar mansion 6, near α Peg). It then passed through BEIDOU (near α UMa) and SHETI (near o and η Boo). This cannot be 12P since it was already situated far south.

Perihelion 813 August 6

The 813 return to perihelion was not perfect concerning the geometrical conditions. The comet may have become brighter than magnitude 6 in July at an elongation of ~ 30°. Maximum brightness with magnitude perhaps 4 was attained at the beginning of August with a similar elongation. The comet then moved southward and became fainter than magnitude 6 in September.

Interestingly, Pingré (1783, pp. 337-338) lists a comet for 813 August 4, but his description (based on the medieval author Theophanes the Confessor) leaves great doubt whether this was indeed a comet: "On August 4 a comet was seen, which resembled two moons joined together; they separated, and having taken different forms, at length appeared like a man without a head" (translation from Chambers 1889, p. 568). The description sounds more like that of a short-lived transient such as a bright meteor/fireball. This object of Theophanes was not included in the catalogues of Williams (1871), Ho (1962), and Hasegawa (1980), and is probably not related to 12P.

Perihelion 742 October 28

The 742 return to perihelion was quite favorable. At the beginning of September, comet 12P would be expected to have become brighter than magnitude 6, while being at an elongation of 65° and a declination of ~ +62°. It then moved southward and attained a maximum magnitude of perhaps 1.5 in October, then with an elongation of 50°-55° and moving in declination from 0° to −20° around its closest approach to the earth.

Despite these favorable observing conditions, no historic object can be identified unambiguously from historical records. Pingré (1783, p. 336) cites several sources for objects around this year. For 742 and 743, Cedreni (1647, pp. 460-461) mentions "a sign in the sky" and "a sign in the sky appearing towards the North, which fell down to the ground like dust", respectively. For 743, Hoyland (2011, p. 242) gives four different chronicles describing a "sign in the sky", which more or less agree with each other probably due to copying. This sign is said to have appeared in June and looked like three "columns of fire that flickered and then remained constant". This sounds very much like an aurora. In June, comet 12P would have been at perhaps magnitude 10. An identity, if real at all, is very unlikely.

Two of the chronicles go on to say that another such sign was seen in September. Here the month would be matching with the visibility of 12P but details are too scarce to suspect it is a misdated description of a comet.

Pingré, Cedreni, and Hoyland all mention another comet seen from Syria in 744 or 745, possibly in January. This object may have also been seen from Asia (Ho, p. 171). Lubienietz says that in 745 a comet was seen in Cancer, according to an anonymous report from the German city of Nuremberg; the comet was seen for 39 days. All of these objects – if real – have probably no relation to comet 12P.

Perihelion 673 January 8

The 673 return to perihelion of comet 12P geometrically falls between the favorable apparitions of 1385 and 1497. The comet would be predicted to have become brighter than magnitude 6 at the beginning of November 672, at an elongation of around 75°. Being at almost +50° declination, it then moved southerly, reaching maximum brightness of perhaps magnitude 2 at the end of the year. The elongation was then around 50°-55° degrees, and the declination around 0°. The comet then continued to move southward and should have become fainter than magnitude 6 in March 673.

Pingré (1783, p. 331) lists a comet for this year – however, with no details that help to decide on any identity with comet 12P/Pons-Brooks. At first, he cites two sentences from ancient chronicles: "In the first year of Thierry's reign, we

saw a Comet. A fire appeared in the sky for ten days. An extraordinary iris caused so much fright, that it was believed that the last day was near." The king mentioned was Theoderic III, who became king of Neustria in 673 and king of Austrasia (and thus of all Franks) in 679. Pingré then concludes: "All this may be reduced to an aurora borealis. Of the Authors quoted [...], only one calls it a comet; while he is contemporary, the word comet is sometimes very ambiguous."

Stryuck (1740, p. 209) wrote: "In the Year 673, in the Month of March, a Fire shined 10 days in the Sky. (*Centuria. Magdeburg.*, cent. 7, cap. 13, p. 564)"; he also suggested identity of the comet of 673 with the 1337 and 1558 comets Stryuck (1753, pp. 19-20). Hevelius (1668, p. 812) and Funccius (p. 124) also mention a comet seen for 10 days in 673.

Lubinietz (1667, p. 116) gives a comet for 674 and refers to Alstedius (1650, p. 506) and Berckringeri (1665, p. 32); the two latter sources are based on de Cesarea (1483), who also gives the phrase with the fire in the skies for ten days.

Asian sources do not help in this case. For the period 672 September 27 to October 25, the Korean Samguk sagi and Jeungbo munheon bigo speak of a "broom star" that "emerged seven times in the north" (Pankenier et al. 2008, p. 74; Ho 1962). This could have been comet 12P if it had been unusually bright and experiencing an outburst.

Perihelion 386 September 8

The return to perihelion in 386 would have produced a quite-favorable apparition. With the end of July, the comet would have appeared in the morning sky at magnitude $\sim$ 6 at an elongation of 46°. At perihelion, the comet would have reached a maximum magnitude of $\sim$ 3.5 at an elongation of 44°; it then started to move southward and would be presumably fainter than magnitude 6 by the end of October at an elongation of 45°.

Pingré (1783, p. 303) reports a comet seen in this year in Sagittarius but says that it was a misdated account of comet C/390 Q1. Ho (1962) reports Asian records that state that there was a comet seen from April/May and disappeared in July/August and situated in Sagittarius. Biot (1843b) noted a comet seen in China in Sgr in April that was visible until July (see also Carl 1864, p. 18). Hasegawa (1980) considered this to be a nova. Since the time and position do not match, an identity with 12P is impossible.

Perihelion 245 September 15

A comet observed in the year 245 is probably an earlier sighting of comet 12P/Pons-Brooks. Pankenier et al. (2008, p. 40) provides: "6th year of the Zhengshui reign period of King Qi of Wei, 8th month, day wuwu [55]; a white broom star 2 chi long appeared in QIXING [LM 25]. It advanced as far as ZHANG [LM 26] for 23 days in total then was extinguished. [Song shu: tianwen zhi] ch. 23".

Other authors (Kronk 1999; Ho 1962; Williams 1871; Pingre 1783) use a slightly different wording as shown as an example in the report by Ho: "On a wu-wu day in the eighth month of the sixth year of the Cheng-Shih reign-period a white (hui) comet measuring 2 ft (chhih) appeared at the Chhi-Hsing (25th lunar mansion) moving towards the Chang (26th lunar mansion) and disappeared after 23 days."

This means that a comet appeared on 245 Sept. 18 (probably Sept. 17.9 UT) close to α, ι, and τ Hya (QIXING or Chhi-Hsing), and moved towards κ, λ, μ, and ν Hya (ZHANG or Chang). The tail was $\sim$ 3° long.

The following derived position assumes that the comet was situated within QIXING: 245 Sept. 17.9, $\alpha = 9^{\rm h}35^{\rm m}$, $\delta = -5°00'$ (equinox J2000.0).

Using Kobayashi's orbit for that epoch, the comet is situated $\sim$ 8° from the above position on 245 Sept. 17.9. Adjusting the perihelion time by +2.9 day QIXING would be around 6°.5 (cf. Figure 5). The brightness would have been magnitude 2-3 around that time.

The general direction of movement then carries the comet indeed in the direction of κ, λ, μ, and ν Hya (also around 7° distance). The problem here is that Pankenier *et al.* say that the comet disappeared after 23 days in the region of ZHANG. This should not have been the case. After 23 days (Oct. 10), it would already be in Cen, some 23° away from ZHANG (or even farther, when using the perihelion date of Sept. 9). All other sources do not connect ZHANG with the date of the last sighting and can be understood as a scenario in which the comet was moving in the direction of ZHANG and disappeared after 23 days, which would agree with the expected path of comet 12P/Pons-Brooks.

Apparently the original text contains some ambiguity in interpretation, and it can indeed be put in both ways. Upon the request from the authors of this paper, a word-by-word translation by Ye (2020b) gives: "...advanced and arrived Zhang and settled for 23 days and then extinguished." From a linguistical point-of-view, it is not fully clear whether the word 'settled' refers to the apparition or to the position of the comet with respect to ZHANG. We nevertheless think that the identification of 12P/Pons-Brooks with the comet of 245 is highly probable and would make it the comet with the second-longest observational arc after 1P/Halley.

6. The apparition of 2024

The impending apparition of 2024 is not very favorable, but will be better than the last one in 1954. An analysis by renowned visual observer Max Beyer (1958) included 76 observations made by himself using the 26-cm equatorial of the Hamburg-Bergedorf observatory (Germany) and show numerous outbursts; he notes that the amplitude of these outbursts decreases with decreasing distance from the sun. At least five outbursts with amplitudes of at least 1 magnitude can be seen in his combined lightcurve of his visual observations and of photographic ones by G. van Biesbroeck. He finally gives lightcurve parameters $H_0 = 4.66$ and $n = 4.33$.

This generally agrees with parameters derived by Green (2020) from observations in the database of the ICQ ($H_0 = 4.0$, $n = 3.2$), which also roughly agree with the limited brightness information for the apparitions of the 19th century. An analysis of historic brightness information in Kronk (2003) confirmed not only the tendency for outbursts but also

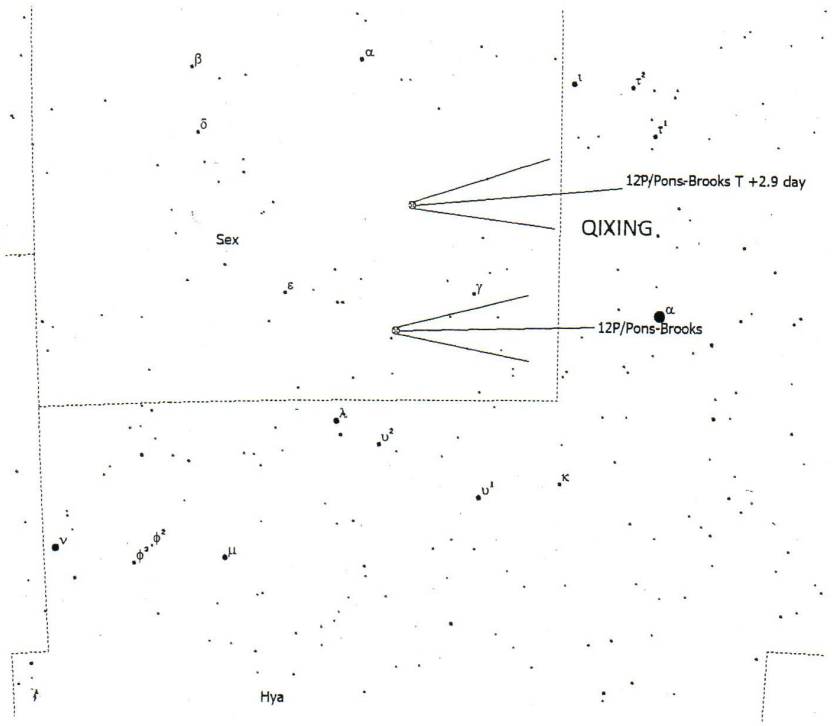


Figure 5: Position of comet 12P/Pons-Brooks in relation to the Chinese constellation QIXING where the comet was seen on 245 Sept. 17.9 UT. Shown are the position based on Kobayashi's nominal linked orbit and after an adjustment of t + 2.9 days.

◇ ◇ ◇

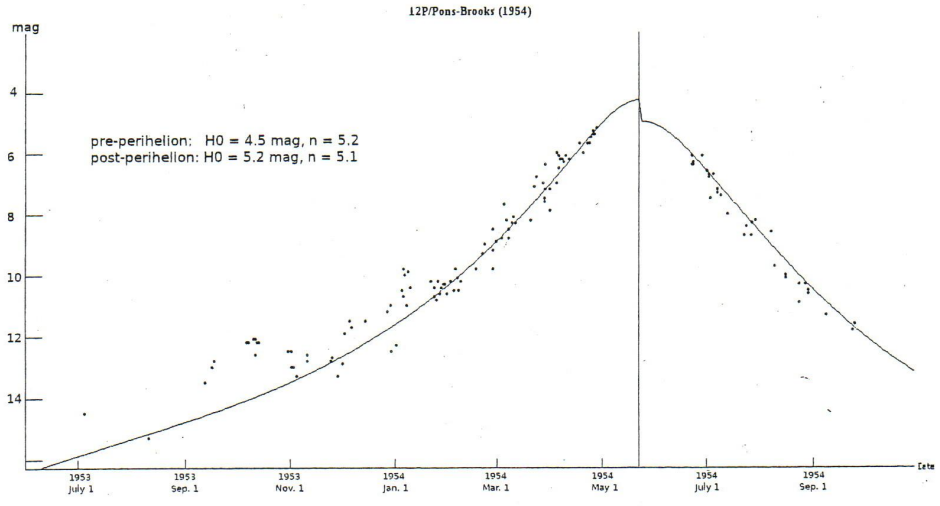


Figure 6: Light curve of comet 12P, 1953-1954, based on the ICQ database and Max Beyer's visual observations (1985).

◇ ◇ ◇

indicated that the comet shows a rather steep decline in brightness after perihelion, hinting to a lightcurve asymmetry. It should also be taken into account that the comet has never been observed at distances farther way than 4.5 AU from the sun pre-perihelion and 2.2 AU post-perihelion. Especially for the pre-perihelion behavior, predictions are very complicated.

A new analysis of the apparition of 1954 using data from the ICQ database and including the observations from Beyer show a clear difference between the pre- and the post-perihelion parts of the lightcurve (cf. Figure 6): pre-perihelion H_0 = 4.5, n = 5.2; post-perihelion H_0 = 5.2, n = 5.1.

Table 3. Ephemeris Comet 12P/Pons-Brooks for 2020-2025.

Date TT	R. A. (2000)	Decl.	Delta	r	Elong.	Phase	Mag(a)	Mag(b)
2020 03 12	18 17.81	+16 22.8	12.557	12.411	79.3	4.5	18.2	24.2
2020 04 21	18 17.16	+18 44.6	11.841	12.200	108.7	4.5	18.1	24.0
2020 05 31	18 07.69	+20 37.1	11.290	11.987	131.5	3.6	17.9	23.8
2020 07 10	17 53.70	+21 05.0	11.064	11.770	132.1	3.7	17.8	23.6
2020 08 19	17 42.81	+19 59.5	11.163	11.550	110.1	4.7	17.7	23.6
2020 09 28	17 40.62	+18 06.7	11.430	11.328	81.6	5.0	17.7	23.5
2020 11 07	17 47.72	+16 29.6	11.643	11.102	54.9	4.2	17.7	23.4
2020 12 17	18 01.02	+15 55.5	11.613	10.873	39.6	3.3	17.6	23.3
2021 01 26	18 15.65	+16 47.2	11.259	10.640	49.1	4.0	17.5	23.1
2021 03 07	18 26.20	+19 01.2	10.636	10.404	73.9	5.3	17.3	22.9
2021 04 16	18 27.77	+22 03.7	9.913	10.164	101.7	5.5	17.0	22.6
2021 05 26	18 18.08	+24 46.4	9.308	9.920	124.7	4.8	16.8	22.3
2021 07 05	18 00.88	+25 49.0	8.993	9.672	129.6	4.6	16.7	22.1
2021 08 14	17 45.81	+24 42.2	8.994	9.420	112.0	5.7	16.6	21.9
2021 09 23	17 41.22	+22 19.7	9.183	9.163	85.7	6.3	16.5	21.8
2021 11 02	17 48.69	+20 07.2	9.352	8.902	60.3	5.6	16.5	21.7
2021 12 12	18 04.79	+19 10.3	9.318	8.635	43.9	4.5	16.3	21.5
2022 01 21	18 23.98	+20 03.5	8.991	8.364	47.9	5.0	16.1	21.3
2022 03 02	18 39.94	+22 52.2	8.402	8.086	68.2	6.5	15.9	20.9
2022 04 11	18 46.04	+27 07.4	7.685	7.803	93.1	7.4	15.6	20.5
2022 05 21	18 36.94	+31 29.9	7.035	7.514	114.7	7.0	15.2	20.1
2022 06 30	18 13.92	+33 53.8	6.618	7.218	122.7	6.8	15.0	19.8
2022 08 09	17 50.09	+32 56.6	6.487	6.915	110.9	7.9	14.8	19.5
2022 09 18	17 40.46	+29 38.9	6.546	6.604	88.9	8.8	14.6	19.2
2022 10 28	17 48.98	+26 16.1	6.614	6.284	66.5	8.3	14.5	19.0
2022 12 07	18 11.31	+24 33.7	6.530	5.956	50.8	7.4	14.3	18.6
2023 01 16	18 40.85	+25 30.4	6.208	5.618	49.4	7.6	14.0	18.2
2023 02 25	19 10.55	+29 32.8	5.663	5.268	61.8	9.5	13.5	17.6
2023 04 06	19 32.17	+36 38.0	4.991	4.907	79.4	11.6	13.0	17.0
2023 05 16	19 33.79	+45 46.6	4.332	4.532	94.9	12.8	12.4	16.2
2023 06 25	18 59.15	+53 48.6	3.807	4.141	102.1	13.9	11.8	15.4
2023 08 04	17 55.68	+55 27.5	3.456	3.734	97.9	15.6	11.3	14.6
2023 09 13	17 19.54	+50 07.6	3.211	3.306	86.5	17.7	10.7	13.8
2023 10 23	17 33.16	+43 09.6	2.952	2.854	74.6	19.6	10.0	12.8
2023 12 02	18 27.92	+38 36.5	2.591	2.376	66.4	22.4	9.1	11.5
2024 01 11	20 06.47	+37 53.3	2.143	1.868	60.6	27.3	7.8	9.7
2024 02 20	22 48.67	+37 21.1	1.751	1.339	49.5	34.1	6.2	7.4
2024 03 31	02 05.11	+23 33.2	1.611	0.875	28.6	33.1	4.6	4.8
2024 05 10	04 31.52	-03 41.3	1.577	0.859	29.6	35.5	4.5	4.6
2024 06 19	07 00.37	-29 55.0	1.578	1.313	55.9	39.9	5.9	7.0
2024 07 29	10 07.58	-44 45.7	1.983	1.842	67.0	30.5	7.6	9.4
2024 09 07	12 40.01	-47 29.2	2.730	2.351	57.7	21.2	9.2	11.5
2024 10 17	14 23.46	-47 30.8	3.520	2.831	40.0	13.1	10.3	13.1
2024 11 26	15 39.66	-47 42.0	4.128	3.283	27.4	7.9	11.2	14.3
2025 01 05	16 36.61	-48 20.5	4.428	3.712	38.8	9.5	11.8	15.1

◇ ◇ ◇

[text continued from page 124]

It should be noted, however, that all post-perihelion estimates come from one observer only (A. Jones) and it is possible that the difference between pre- and post-perihelion is due to observer bias. The lightcurve also shows that the tendency for small outbursts is much more apparent prior perihelion.

The ephemeris above uses the values of Green, labelled Mag(a), and the pre-perihelion parameters from the new analysis, labelled Mag(b).

REFERENCES

Alstedius, J. H. (1650). *Thesaurus Chronologiae* (Herbornae).

Berckringeri, D. (1665). *Dissertatio Histrorico-Politica de Cometis* (Ultrajectum: Meinard).

Beyer, M. (1958). "Physische Beobachtungen von Kometen. X", *A.N.* **284**, 112-128.

Biot, E. C. (1843a). "Catalogue Des Comètes observées en Chine depuis l'an 1230 jusqu'à l'an 1640 de notre ère", in *Connaissance des Temps ... Pour L'An 1846* (Paris: Bachelier, Imprimeur-Libraire du Bureau des Longitudes), Additions, p. 57.

Biot, E. C. (1843b). "Catalogue Des Étoiles extraordinaires observéns en Chine depuis les temps anciens jusqu'à l'an 1203 de notre ère", in *Connaissance des Temps ... Pour L'An 1846* (Paris: Bachelier, Imprimeur-Libraire du Bureau des Longitudes), Additions, p. 64.
Carl, P. (1864). *Repertorium der Cometen-Astronomie* (Muenchen: M. Rieger'sche Universitaets-Buchhandlung).
Cedreni, G. (1647). *Compendium Historiarum. Tomus II* (Paris).
Celoria, G. (1884). "Comete del 1457", *A.N.* **110**, 174.
Celoria, G. (1894). "Con un capitolo sui lavori astronomici del Toscanelli", in *Raccolta di documenti e studi pubblicati dalla R. Commissione colombiana* (Roma: Ministero della pubblica istruzione), part. 5, vol. 2.
Celoria, G. (1921). "Sulle osservazioni di comete fatte da Paolo Dal Pozzo Toscanelli e sui lavori astronomici in generale", *Pubblicazioni del Reale Osservatorio Astronomico di Brera in Milano*, 55.
Chambers, G. F. (1889). *A Handbook of Descriptive and Practical Astronomy*, 4th ed. (Oxford: Clarendon Press), Vol. 1.
de Cesarea, E. (1483). *Chronicon* (Venezia: Erhard Ratdolt).
Festou, M. C.; B. Morando; and P. Rocher (1985). "The orbit of periodic comet Crommelin between the years 1000 and 2100", *Astron. Astrophys.* **142**, 421-429.
Funccio, J. (1578). *Chronologia* (Witebergae).
Galle, J. C. (1894). *Verzeichniss der Elemente der bisher berechneten Cometenbahnen* (Leipzig: Verlag von Wilhelm Kugelmann).
Gould, G. P., transl. (1977). *Manilius: Astronomica* (Cambridge, MA: Harvard University Press), p. 77.
Green, D. W. E. (2020a). *CBET* No. 4727.
Green, D. W. E. (2020b). *CBET* No. 4805.
Hasegawa, I. (1979). "Orbits of ancient and medieval comets", *Publ. Astron. Soc. Japan* **31**, 257-270.
Hasegawa, I. (1980). "Catalogue of Ancient and Naked-Eye Comets", *Vistas Astron.* **24**, 59-102.
Hevelius, J. (1668). *Cometographia, totam naturam cometarum* (Gedani, Simon Reininger).
Hind, J. R. (1846). "Schreiben des Herrn J. R. Hind an den Herausgeber", *A.N.* **23**, 177.
Ho, P. Y. (1962). "Ancient and mediaeval observations of comets and novae in Chinese sources", *Vistas Astron.* **5**, 127-225.
Hoyland, R. G. (2011). *Theophilus of Edessa's Chronicle*, Translated Texts for Historians, vol. 57 (Liverpool Univ. Press).
Jervis, J. L. (1985). *Cometary Theory in Fifteenth-Century Europe*, Studia Copernicana (Wroclaw).
Kobayashi, T. (2020). *Nakano Note* No. 4136 (2020 June 28).
Kobayashi, T. (2021). Re-reduced 19th-century astrometry of comet 12P available via website URL `http://www.icq.eps.harvard.edu/icqobs.html`.
Kronk, G. W. (1999). *Cometography*, Vol. 1 (Cambridge University Press).
Kronk, G. W. (2003). *Cometography*, Vol. 2 (Cambridge University Press).
Kronk, G. W. (2007). *Cometography*, Vol. 4 (Cambridge University Press).
Lubienietz, S. (1667). *Systematis Cometici Tomus Secundus . . . Theatri Cometici pars posterior . . . Historia Cometarum, . . .* (Amsterdam: Francisco Cuyper).
Marsden, B. G. (1975). *Catalogue of Cometary Orbits*, 2nd ed. (Cambridge, MA: Smithsonian Astrophysical Observatory).
Meyerus Baliolanus, J. M. (1561). *Commentarii sive annales rerum Flandricarum* (Anvers: Steelsius).
Mussati, A. (1723). "Historia Augusta", *Rerum Italicarum Scriptores.* Tomus Decimus. Mediolanum. (Flandricarum).
Nakano, S. (2020a). *Nakano Note* No. 4048 (2020 Mar. 3).
Nakano, S. (2020b). *Nakano Note* No. 4136 (2020 June 28).
Niebuhr, B. G., ed. (1838). Corpus Scriptorum Historiae Byzantinae. Theophanes Continuatus (Bonn: Impensis Ed. Weberi).
Pankenier, D. W.; Z. Xu; and Y. Jiang (2008). *Archaeoastronomy in East Asia* (Amherst, NY: Cambria Press).
Park, S.-Y.; and J. Chae (2007). "Analysis of Korean Historical Comet Records", *Publ. Korean Astron. Soc.* **22**, 151-168.
Peirce, B. (1846). *American Almanac for 1847*, p. 83.
Pingré, A. G. (1783). *Cometographie ou traite historique et theoretique des cometes. Tome premier* (Imprimerie Royale, Paris).
Procter, M.; and A. C. D. Crommelin (1937). *Comets: Their Nature, Origin, and Place in the Science of Astronomy* (The Technical Press, London).
Ramsey, J. T.; and A. L. Licht (1997). *The Comet of 44 B.C. and Caesar's Funeral Games* (Atlanta, GA: Scholar's Press), p. 94.
Schulhof, L. (1885). "Ueber muthmassliche frühere Erscheinungen des Cometen 1873 VII", *A.N.* **113**, 143-144.
Stephenson, F. R. (1997). *Historical Eclipses and Earth's Rotation* (Cambridge University Press), p. 515.
Struyck, N. (1740). "Inleiding tot de Algemeene Kennis der Comeeten, of Staarsterren", in *Inleiding tot de Algemeene Geographie, benevens eenige Sterrekundige en andere Verhandelingen* (Amsterdam: Isaak Tirion).
Struyck, N. (1753). "Vervolg van de Beschryving der Comeeten of Staartsterren", in *Vervolg van de Beschryving der Staartsterren, en Nader Ontdekkingen Omtrent den Staat van 't Menschelyk Geslagt* (Amsterdam: Isaak Tirion).
Sueyro, E. (1624). *Anales de Flandes, Segunda Parte* (Anvers: Pedro y Iuan Belleros).
Tackio, J. (1653). *Coeli Anomalon, id est, De Cometis, sive Stellis Crinitis ...* (Giessen, Germany: Ex officina Typographica Chemliniana).
Werlauff, E. C. (1847). *Íslenzkir annálar, sive Annales Islandici ab anno Christi 803 ad annum 1430* (sumptibus Legati Arnae-Magnaeani).

Williams, J. (1871). *Observations of Comets from BC 611 to AD 1640* (London: Stangeways and Walden).
Wyttenbach, J. H., Müller, M. F. J. (1838). *Gesta Trevirorum integra lectionis varietate et animadversionibus illustrata ac indice duplici instructa*, Vol. II (Trier: Lintz).
Ye, Q. et. al. (2020a). "Recovery of Returning Halley-Type Comet 12P/Pons-Brooks with the Lowell Discovery Telescope", *RNAAS* **4**, No. 7, 2020 July 7.
Ye, Q. (2020b). Personal communication.
Hind, J. R. (1846). "Schreiben des Herrn J. R. Hind an den Herausgeber", *A.N.* **23**, 177.
Ho, P. Y. (1962). "Ancient and mediaeval observations of comets and novae in Chinese sources", *Vistas Astron.* **5**, 127-225.
Hoyland, R. G. (2011). *Theophilus of Edessa's Chronicle*, Translated Texts for Historians, vol. 57 (Liverpool Univ. Press).
Jervis, J. L. (1985). *Cometary Theory in Fifteenth-Century Europe*, Studia Copernicana (Wroclaw).
Kobayashi, T. (2020). *Nakano Note* No. 4136 (2020 June 28).
Kobayashi, T. (2021). Re-reduced 19th-century astrometry of comet 12P available via website URL `http://www.icq.eps.harvard.edu/icqobs.html`.
Kronk, G. W. (1999). *Cometography*, Vol. 1 (Cambridge University Press).
Kronk, G. W. (2003). *Cometography*, Vol. 2 (Cambridge University Press).
Kronk, G. W. (2007). *Cometography*, Vol. 4 (Cambridge University Press).
Lubienietz, S. (1667). *Systematis Cometici Tomus Secundus . . . Theatri Cometici pars posterior . . . Historia Cometarum, . . .* (Amsterdam: Francisco Cuyper).
Marsden, B. G. (1975). *Catalogue of Cometary Orbits*, 2nd ed. (Cambridge, MA: Smithsonian Astrophysical Observatory).
Meyerus Baliolanus, J. M. (1561). *Commentarii sive annales rerum Flandricarum* (Anvers: Steelsius).
Mussati, A. (1723). "Historia Augusta", *Rerum Italicarum Scriptores.* Tomus Decimus. Mediolanum. (Flandricarum).
Nakano, S. (2020a). *Nakano Note* No. 4048 (2020 Mar. 3).
Nakano, S. (2020b). *Nakano Note* No. 4136 (2020 June 28).
Niebuhr, B. G., ed. (1838). *Corpus Scriptorum Historiae Byzantinae. Theophanes Continuatus* (Bonn: Impensis Ed. Weberi).
Pankenier, D. W.; Z. Xu; and Y. Jiang (2008). *Archaeoastronomy in East Asia* (Amherst, NY: Cambria Press).
Park, S.-Y.; and J. Chae (2007). "Analysis of Korean Historical Comet Records", *Publ. Korean Astron. Soc.* **22**, 151-168.
Peirce, B. (1846). *American Almanac for 1847*, p. 83.
Pingré, A. G. (1783). *Cometographie ou traite historique et theoretique des cometes. Tome premier* (Imprimerie Royale, Paris).
Procter, M.; and A. C. D. Crommelin (1937). *Comets: Their Nature, Origin, and Place in the Science of Astronomy* (The Technical Press, London).
Ramsey, J. T.; and A. L. Licht (1997). *The Comet of 44 B.C. and Caesar's Funeral Games* (Atlanta, GA: Scholar's Press), p. 94.
Schulhof, L. (1885). "Ueber muthmassliche frühere Erscheinungen des Cometen 1873 VII", *A.N.* **113**, 143-144.
Stephenson, F. R. (1997). *Historical Eclipses and Earth's Rotation* (Cambridge University Press), p. 515.
Struyck, N. (1740). "Inleiding tot de Algemeene Kennis der Comeeten, of Staarsterren", in *Inleiding tot de Algemeene Geographie, benevens eenige Sterrekundige en andere Verhandelingen* (Amsterdam: Isaak Tirion).
Struyck, N. (1753). "Vervolg van de Beschryving der Comeeten of Staartsterren", in *Vervolg van de Beschryving der Staartsterren, en Nader Ontdekkingen Omtrent den Staat van 't Menschelyk Geslagt* (Amsterdam: Isaak Tirion).
Sueyro, E. (1624). *Anales de Flandes, Segunda Parte* (Anvers: Pedro y Iuan Belleros).
Tackio, J. (1653). *Coeli Anomalon, id est, De Cometis, sive Stellis Crinitis ...* (Giessen, Germany: Ex officina Typographica Chemliniana).
Werlauff, E. C. (1847). *Íslenzkir annálar, sive Annales Islandici ab anno Christi 803 ad annum 1430* (sumptibus Legati Arnae-Magnaeani).
Williams, J. (1871). *Observations of Comets from BC 611 to AD 1640* (London: Stangeways and Walden).
Wyttenbach, J. H., Müller, M. F. J. (1838). *Gesta Trevirorum integra lectionis varietate et animadversionibus illustrata ac indice duplici instructa*, Vol. II (Trier: Lintz).
Ye, Q. et. al. (2020a). "Recovery of Returning Halley-Type Comet 12P/Pons-Brooks with the Lowell Discovery Telescope", *RNAAS* **4**, No. 7, 2020 July 7.
Ye, Q. (2020b). Personal communication.

Φ Φ Φ