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

Maik Meyer\textsuperscript{1}, Takao Kobayashi\textsuperscript{2}, Syuichi Nakano\textsuperscript{3}, Daniel W. E. Green\textsuperscript{4}

\textsuperscript{1} Limburg, Germany
\textsuperscript{2} Oizumi, Gunma-ken, Japan
\textsuperscript{3} Sumoto, Japan
\textsuperscript{4} Harvard University, Cambridge, MA, USA

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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 its perihelion passage 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°. 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 contemporary 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 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.”

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

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 cometeraphers 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° long; 1 cun is about 0.1°. 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.
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 orbit by Celoria is given here for reference

\[ q = 0.703 \text{ AU}, \text{peri} = 195^\circ, \text{node} = 258^\circ, i = 13^\circ \]

### 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 \( \beta \) Vir and left the area of \( \beta \) and \( \eta \) Vir. On 1385 October 30, the comet entered Crater; on November 4 it ’trespassed against’ an asterism in Hydra. The comet had a 10-degree 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 similar 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. The orbits (2000.0) derived by Peirce (1846), Hind (1846) and Hasegawa are given here for reference.

- **Peirce:** \( q = 0.755 \text{ AU}, \omega = 155^\circ, \Omega = 270^\circ, i = 105^\circ \)
- **Hind:** \( q = 0.738 \text{ AU}, \omega = 130^\circ, \Omega = 296^\circ, i = 52^\circ \)
- **Hasegawa:** \( q = 0.79 \text{ AU}, \omega = 289^\circ, \Omega = 103^\circ, i = 103^\circ \)

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 colours. A similar account can be found in a later annal by E. Sueyro (1624) with the only difference 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 which 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.

| 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 |   |

| 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 in Green (2020a) and Nakano (2020a).

Prompted by these announcements, the comet was recovered on June 10 and 17, 2020, 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)).

Including these recovery observations the following linked orbital elements were derived. These observations are listed in Table 1. 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.

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 = 0.013564  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
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 Hasegawa.

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.
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 \( \leq 40^\circ - 50^\circ \), 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 2: Orbital elements by T. Kobayashi for 12P/Pons-Brooks, based on observations from 1385-2020.

| Year | Day | Hour | Right Ascension (h:m:s) | Declination (°) | Epoch | Distance (AU) | Magnitude |
|------|-----|------|-------------------------|----------------|-------|--------------|-----------|
| 0012 | 33  | 03   | 24.392 0.783058         | 0.955528       | 201.801 | 253.835      | 73.443    |
| 0012 | 105 | 08   | 27.621 0.777178         | 0.955319       | 201.719 | 253.956      | 73.656    |
| 0012 | 176 | 05   | 17.343 0.774058         | 0.954814       | 201.597 | 254.078      | 73.899    |
| 0012 | 245 | 09   | 15.466 0.772882         | 0.954562       | 201.409 | 254.157      | 74.028    |
| 0012 | 315 | 03   | 12.893 0.785689         | 0.954230       | 201.456 | 254.037      | 73.992    |
| 0012 | 386 | 09   | 08.388 0.787368         | 0.954884       | 201.372 | 254.025      | 73.741    |
In the following 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° 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 description 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 unfavourable 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. Porphyrg. 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, than 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. Maximum magnitude of 4.5 was attained at
an elongation of 22°. It then moves southward and became fainter than magnitude 6 in mid-May at an elongation of about 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 φ and η Boo). This can not 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 about 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, Pingre (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 about +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. Pingre (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.

Pingre, Cedreni and Hoyland 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 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°, and the declination around 0°. The comet then continued to move southward and should have become fainter than magnitude 6 in March 673.

Pingre (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. Pingre 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 about magnitude 6 at an elongation of 46°. At perihelion, the comet would have reached a maximum magnitude of about 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°.

Pingen (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; Pingen 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 17.9 UT) close to α, τ, and τ Hya (QIXING or Chhi-Hsing), and moved towards κ, λ, μ, and ν Hya (ZHANG or Chang). The tail was about 3° long.

The following derived position assumes that the comet was situated within QIXING.

245 Sep 17.9: 09h 35m −05° 00’ (2000.0).

Using Kobayashi’s orbit for that epoch, the comet is situated about 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. fig. 5). The brightness would have been at magnitude 2-3 around that time.
The general direction of movement then carries the comet indeed in the direction of $\kappa$, $\lambda$, $\mu$, and $\nu$ 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 third-longest observational arc after 1P/Halley and 109P/Swift-Tuttle.

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 shows 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 mag 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 of H0 = 4.66 mag and n = 4.33.

This generally agrees with parameters derived by Green (2020) from observations in the database of the ICQ (H0 = 4.0 mag, 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 showed 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 (fig. 6).

pre-perihelion: H0 = 4.5, n = 5.2
post-perihelion: H0 = 5.2, n = 5.1

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.

Figure 6: Lightcurve of comet 12P/Pons-Brooks based on the ICQ database and Max Beyer’s visual observations (1958). (Lightcurve prepared with “Comet for Windows”, URL http://www.aerith.net/project/comet.html)

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

| Date   | TT    | R. A. (2000) | Decl. | Delta | 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 |
| Date       | Time     | Daylight | Local Hour | Universal Time | Universal Hour | Air Mass | Air Mass | Altitude  | Declination | Brightness | Brightness | Brightness |
|------------|----------|----------|------------|----------------|----------------|----------|----------|-----------|-------------|------------|------------|------------|
| 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     | 10.636         | 73.9           | 5.3      | 17.3     | 22.9      |
| 2021 02 05 | 18 27.77 | +22 03.7 | 9.913      | 10.164         | 101.7          | 4.5      | 16.8     | 22.6      |
| 2021 03 07 | 18 26.20 | +19 01.2 | 9.308      | 8.920          | 49.1           | 4.0      | 16.5     | 22.1      |
| 2021 04 16 | 18 27.77 | +22 03.7 | 9.318      | 8.635          | 43.9           | 4.5      | 16.3     | 21.5      |
| 2021 05 26 | 18 18.08 | +24 42.2 | 8.994      | 9.420          | 112.0          | 5.7      | 16.6     | 21.9      |
| 2021 07 05 | 18 00.88 | +25 49.0 | 8.993      | 9.672          | 129.6          | 4.6      | 16.7     | 21.2      |

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