Comet 12P/Pons-Brooks
-
Identical to comets C/1457 A1 and C/1385 U1

Maik Meyer, Version of March 8, 2020

The first detection of the identity was made while backward integrating the orbit for 12P until about the year 1000. The calculations used data from the apparitions of 1883/84 and 1953/54 (taken from the MPC database). From the integration it was apparent that the orbit is quite stable and does not undergo strong perturbations in the covered period. Checking the different Cometographies I quickly saw that the first comet of 1457 and the comet of 1385 were almost perfect matches if one looked at the perihelion time. I checked my backward integrated orbits with the catalogue orbits within the GUIDE software and it was apparent that the 12P orbits I derived are fully compatible with the observed paths and and observational circumstances of the 1457 and 1385 objects. By adjusting my orbits only by a few days in perihelion time the match could be brought even closer.

After contacting S. Nakano he provided backward integrated orbits derived by T. Kobayashi from newly reduced observations of all three known apparitions (1812-1954). These orbits were fully compatible with my orbits and showed the same perihelion dates I derived by adjusting my orbits. In the course of the following days I derived positions for the 1457 and 1385 comet, which were then used by T. Kobayashi to calculate new, linked orbits, which were published in CBET 4727 [1].

The new orbits by Kobayashi derived from linking the apparitions of 1385, 1457, 1812, 1884, and 1954 are as follows from 1062 observations spanning 1385-1954 (weighted mean residual 1".5), with non-gravitational parameters A1 = -0.07 ± 0.00, A2 = -0.0270 ± 0.0000.:

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                Epoch = 1385 Nov.  8.0 TT
T = 1385 Nov.  6.219 TT          Peri. = 200.024
e = 0.95506                      Node  = 255.125   2000.0
q = 0.78362 AU                   Incl. =  73.829
  a = 17.43756 AU     n = 0.013536     P =  72.82 years

                Epoch = 1457 Jan. 14.0 TT
T = 1457 Jan. 30.0223 TT         Peri. = 199.8935
e = 0.954812                     Node  = 255.2503  2000.0
q = 0.778447 AU                  Incl. =  74.0398
  a = 17.227035 AU    n = 0.0137844    P =  71.50 years
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C/1457 A1

The until now accepted orbit for this comet is by G. Celoria derived from Toscanelli's observations made daily between January 23 and 27, 1457. Celoria published this in 1921 in "Pubblicazioni del Reale Osservatorio astronomico di Brera in Milano" [2] (which is a republication of a paper of 1894 [3]). The orbit is based on 3 observations and the comparison with the other available observations. It should be noted that Celoria already published an orbit and some explanations in *Astronomische Nachrichten* in 1884 [4].

Images of the drawing by Toscanelli and Celoria's interpretation can be found at http://www.atlascoelestis.com/Toscanelli_1457_francobolli.htm. I will include these in this paper as soon as I have received my copy of Celoria's book.

Celoria gives some explanation about how he identified the star fields. Apparently Toscanelli had given a scale on his maps which allowed identification of the star fields. In the *Astronomische Nachrichten* Celoria writes (translated from Italian):

> "The other observations made by Toscanelli in 1457 concern the Comet that appeared in January of that year, of which also the Chinese Chronicles make brief mention. There are few observations made between the 23rd and 27th of January, and they are drawn in the chart 241 recto of the already mentioned Magliabechian Code. The stars are put in this chart in place with some precision; next to the first position of the Comet the date January 23rd 1457 is written explicitly; next to the others are written the progressive numbers from 24th to 27th; tail traces are drawn every day about half a degree long. It was not difficult to identify the main ones among the stars contained in this chart, and then to deduce by means of special instructions the following positions of the comet."

However, as can be seen from the images that the accuracy can only be good to maybe a few degrees and any orbit derived from it is prone to some considerable uncertainty.

There is another book by Jane L. Jervis which gives some details on Toscanelli's drawings and Celoria's analysis [5]. She writes:

> "Toscanelli's observations of this comet extend from January 23 through 27, 1457, and appear only on fol. 240 r[…]. This page has a coordinate grid engraved on it, the longitude extending across the middle of the page from Pisces 15° to Taurus 22°, and the latitude indicated very faintly at the beginning of Aries […]. The coordinate grid was rather sloppily done so that the latitude lines of the left half of the page do not exactly coincide with those on the right."
>
> "[…] Celoria […] determines that Toscanelli had taken his stellar positions from the *Almagest* catalog. He computes the orbital elements […] using modern star positions, plotting the cometary positions by alignment with Toscanelli's fixed stars, and taking the probably time of observation, not given in the manuscript, as 6: 22 p.m., when the sky was dark and the comet was still fairly high."

The next image shows a comparison of the movement of 12P and the C/1457 A1 based on Kobayashi-san's orbit and Celoria's orbit. None of both is adjusted, they are just used as they were originally given.

It can be seen that both were moving in the same area at the same time. One should not give to much emphasis on the inclination of both orbits to each other: As already mentioned it is clear that from Toscanelli's drawing also the 12P orbit could be derived from it; it is simply too crude to obtain positions and the direction of motion with great precision. What can be said, however, is that at that time a comet was moving with a certain brightness and sense of motion and that 12P fits it very well.

Another note should be given: There exists a Chinese observation of the 1457 comet (also mentioned above) that, however, bears a problem: Ho Peng Yoke (1962) says that a comet was seen on January 14 in the constellation "*Pi* (19th lunar mansion) […] It moved towards the SE and gradually increased in length." It went out of sight on January 23 [6]. The problem is that the constellation *Pi* is near α and ε Tau and that 12P would be near ω Psc and γ Peg on that date. The Chinese position, by the way, is not at all compatible with the Toscanelli observations, except there is an error in the Chinese sources. Ho Peng Yoke shows in his charts at the end of his paper that the area near γ Peg is also named as *Pi* but in the 14th lunar mansion and not in the 19th! So if the 14th and 19th lunar mansion were mixed up then 12P would be correctly placed on January 14 while Celoria's orbit shows it further away from there - adding even more weight to the ID with 12P/Pons-Brooks!

Finally, another argument for the ID with 12P: Based on the derived magnitude parameters of the last apparition the magnitude of 12P was probably 3-4 mag (the comet being close to perihelion and about 0.95 AU from Earth). This would explain why it was not such a conspicuous object and followed only for a short time. Even more, if Celoria's orbit would be correct, the comet would have brightened further with increasing elongation in the following time. This is not consistent with the observations. 12P, on the other hand, would have become fainter with very slowly increasing elongation, consistent with the observations.

I should mention that this comet was long suspected to be identical with 27P/Crommelin. This had been brought up by Schulhof [7] and later by Procter and Crommelin [8] himself. However, modern calculations were not able to confirm this, moreover, it could be ruled out later (cf. Marsden [9], Festou, Morando and Rocher [10]).

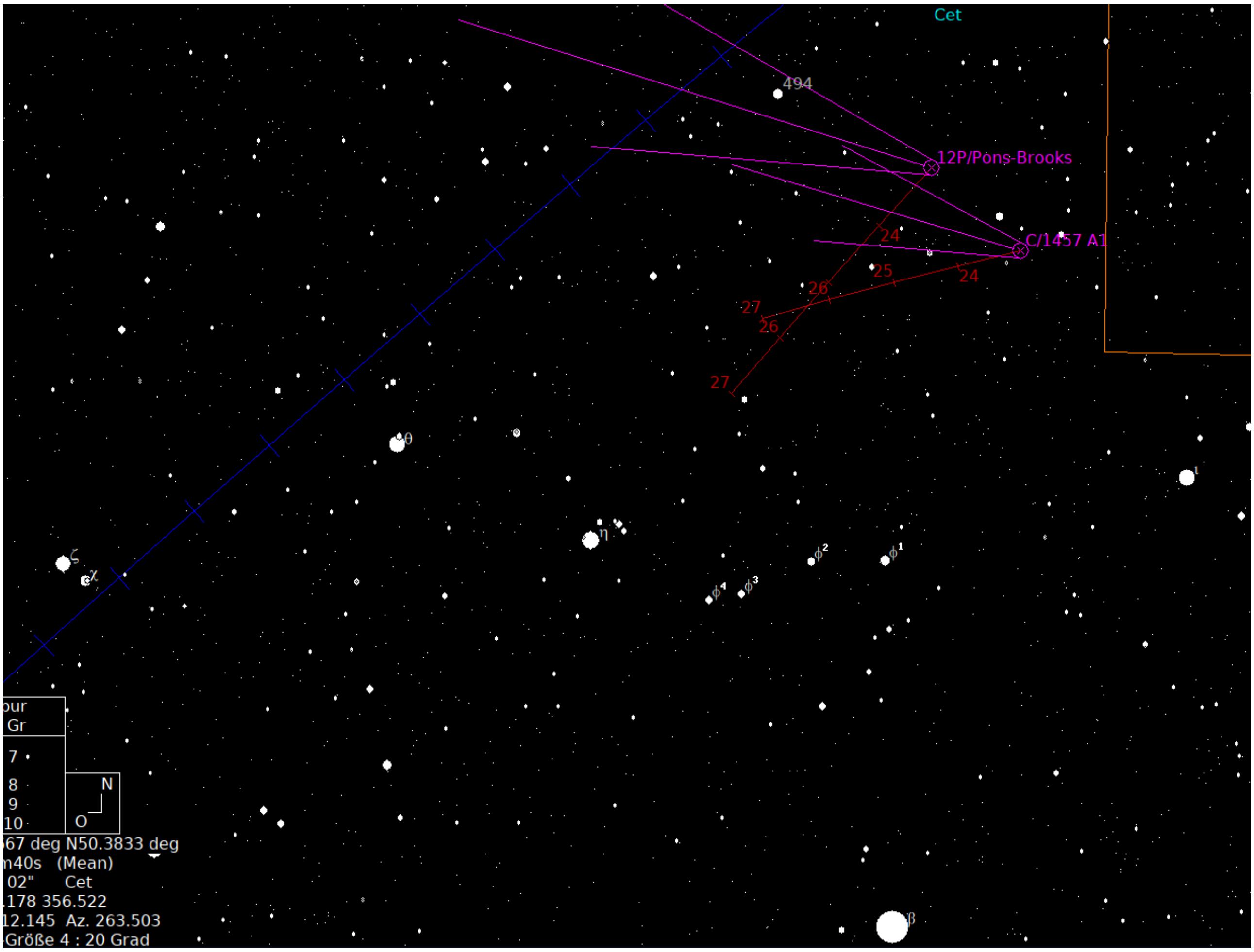

Fig. 3: Apparent paths of comet C/1457 A1 based on Celoria's orbit and 12P. Chart prepared with GUIDE planetarium software (www.projectpluto.com).

C/1385 U1

For the 1385 apparition we only have the description of the movement from Asian sources. The accepted orbit by Hasegawa of course resembles this general movement. On October 23, it appeared near *Coma Berenices*, *Leo* and *Virgo*, moved after that towards β Vir and left the area of β and η Vir. On October 30 it entered *Crater*. On November 4 it "trespassed against" an asterism in *Hydra*. Let's have a look at the general movement during the time of observation (Oct. 22.9 – Nov. 3.9) in the image below.

It can be seen that the orbit of 12P is perfectly consistent with the above description and moves similar to comet C/1385 U1 – <u>it fits the description even better</u>! Again, for the image below Kobayashi-san's orbit was not adjusted in any way.

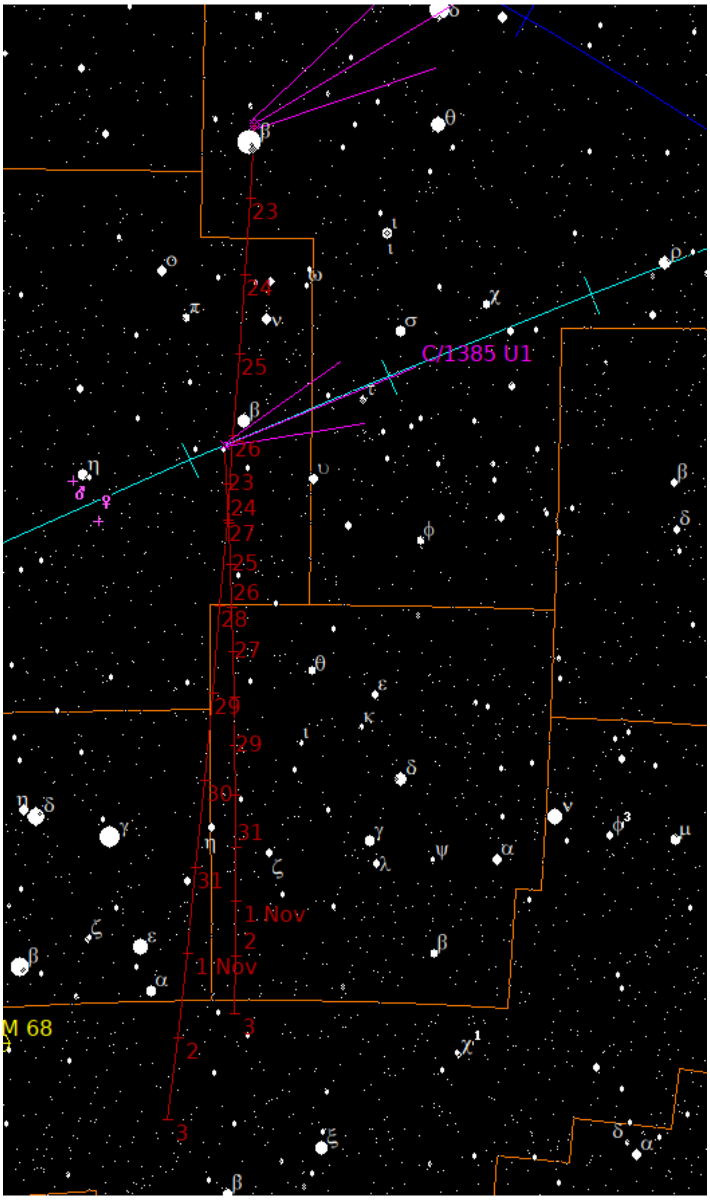

Fig. 4: Apparent paths of comet C/1385 U1 based on Hasegawa's orbit and 12P. Chart prepared with GUIDE planetarium software (www.projectpluto.com).

Using the magnitude parameters from the last apparitions the brightness was probably 2 mag since the apparition was very favorable (close approach to Earth). This agrees well with the Asian observations.

Discussion of sightings at other apparitions

With the now firmly established orbit one can exactly check whether the comet has been seen at other apparitions. Even 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 which were quite constant between 1385 and now.

It has to be stressed that for a comet to be noticed without a telescope it needs to be in dark skies (elongation > 40-50°) at a certain brightness (brighter than 3-4 magnitudes). For most of the apparitions below this is not the case. The apparitions of 1457 and 1385 were very favourable where the comet was close to Earth and bright enough to be easily seen. 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.

1740

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Epoch = 1740 June 28.0 TT
 T = 1740 July 14.0011 TT         Peri. = 199.3661
 e = 0.955378                     Node  = 255.5134  2000.0
 q = 0.779450 AU                  Incl. =  73.8999
   a = 17.468007 AU    n = 0.0135002    P =  73.01 years
```

This apparition was not favorable concerning the observing geometry. The comet might have reached 10 mag in April, but already at an elongation below 50°. In May the brightness may have attained 8 mag but the elongation was then below 40°. Perihelion was reached almost behind the sun, the elongation being then around 13°, the brightness maybe 4 mag. The comet then moved quickly southward and remained at elongations below 45°. There is also no promising candidate in other records to be found.

1668

```
Epoch = 1668 Apr. 26.0 TT
T = 1668 Apr. 17.3669 TT         Peri. = 199.4353
e = 0.955188                     Node  = 255.3886  2000.0
q = 0.777543 AU                  Incl. =  73.9791
  a = 17.351235 AU    n = 0.0136367    P =  72.28 years
```

This apparition was also not favorable with the observing geometry being very bad. In January the comet might have been at 9 mag at elongations of just below 60°. Perihelion was reached at only 22° elongation with a magnitude of maybe 4 mag.

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 [11] a comet is mentioned that was seen by Korean observers from March 11. While Park and Chae attribute this object to 12P it more likely to have another description of C/1668 E1. It would have been strange to see another bright comet in the generally same region of the sky as another comet that was observed widely throughout the world. And it again has to be stressed that 12P was at magnitude 11 at March 11! It would have taken a very large and long-lived outburst to bring it to a magnitude to be seen for the unaided eye by the Koreans (and only by the Koreans!).

1597

```
Epoch = 1597 June 18.0 TT
T = 1597 July  3.7407 TT         Peri. = 199.5740
e = 0.954803                     Node  = 255.4101  2000.0
q = 0.777694 AU                  Incl. =  74.0596
  a = 17.206755 AU    n = 0.0138088    P =  71.38 years
```

1597 saw another unfavorable apparition, similar to or even worse than the one of 1740. There is also no candidate record in historic sources.

1527

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Epoch = 1527 Mar. 28.0 TT
T = 1527 Mar. 12.5870 TT          Peri. = 199.7115
e = 0.954685                      Node  = 255.3258  2000.0
q = 0.776593 AU                   Incl. =  74.1056
  a = 17.137757 AU    n = 0.0138923    P =  70.95 years
```

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

1313

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Epoch = 1313 May  10.0 TT
T = 1313 Apr. 30.851 TT           Peri. = 200.080
e = 0.95512                       Node  = 254.962   2000.0
q = 0.78444 AU                    Incl. =  73.812
  a = 17.47913 AU     n = 0.013487     P =  73.08 years
```

The next perihelion before 1385 was in 1313 and it was again a not favorable apparition. The comet remained at low elongations and perihelion was attained with about 4 mag at elongations below 15°.
Park and Chae have suggested this comet as a candidate for 12P, too. There was indeed a comet seen on 1313 April 13, about 1.5 months prior perihelion (5 mag, 15° elongation). 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.

1241

```
Epoch = 1241 Apr. 18.0 TT
T = 1241 Apr. 10.973 TT           Peri. = 200.177
e = 0.95487                       Node  = 254.899   2000.0
q = 0.78394 AU                    Incl. =  73.886
  a = 17.36898 AU     n = 0.013616     P =  72.39 years
```

Again, another unfavorable apparition comparable to the apparitions above with perihelion times in spring. Historic records show possible comets in 1240 (C/1240 B1) and 1242, but both can be ruled out.

1170

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Epoch = 1170 Feb. 10.0 TT
T = 1170 Feb. 24.085 TT           Peri. = 200.271
e = 0.95450                       Node  = 254.844   2000.0
q = 0.78128 AU                    Incl. =  74.040
  a = 17.17277 AU     n = 0.013850     P =  71.16 years
```

This apparition was not as unfavorable as the ones before but also not perfect. The comet attained a brightness of magnitude 9 maybe in November 1169 at an elongation of just above 70°. It reached perihelion at magnitude 3.5 at an elongation of 37°. There are historical records for objects in 1166 and 1175, but the descriptions do not fit even if we assume an error in the given year. Another uncertain object is listed for 1171 December, but here the year is uncertain and only the “west” is given as positional data.

Further back in time

There might be earlier sightings but the records become scarce and even more uncertain the further we go back in time. I have checked apparitions back until 813 and only the apparition of 959, which is similar to that of 1457, showed up as a good candidate based on the observing geometry. There is one comet shown in 959, but the details are very uncertain. They come from a Byzantine text of 990 and give not observational details but rather relate it to the death of Constantine VII Porphyrogenitus (who died on November 9) [12]. The comet was then expected to be bright in January… I. Hasegawa [13] gives a date of Oct. 17 for this comet and lists another for 959 May, seen from Arabia.

Taking only into account the observing geometry it becomes clear that only the apparitions of 959, 1385 and 1457 were favorable enough for 12P/Pons-Brooks to be seen with the naked eye.

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