Comet Section

A major outburst of comet 12P/Pons–Brooks

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It was Jean-Louis Pons at Marseille who discovered this object, whilst sweeping the morning sky on 1812 Jul 21.[1] The comet reached perihelion on 1812 Sep 15 and calculations showed that it had an orbital period of around 70 years. On 1883 Sep 2, William Brooks in New York State discovered a comet which turned out to be the same object.[2] 12P/Pons–Brooks came to perihelion on 1884 Jan 26, and it was an easy naked-eye object at its brightest. It also had a significant outburst on 1884 Sep 22, when it suddenly brightened by two to three magnitudes.

12P is a Halley-type comet with a current period of 71 years and a perihelion distance, *q*, of 0.78 astronomical units (au). The last return was in 1954. On 1953 Jun 20, the comet was recovered by Elizabeth Roemer using the 36-inch Crossley reflector at Lick. This was around 11 months before perihelion, which occurred on 1954 May 22, and we have some drawings by George Alcock in our archive which show how it looked back then (Figure 1).

The next perihelion will be on 2024 Apr 21. The comet should reach 4th magnitude early next year and so will be an interesting object to follow. This time around, the comet was recovered using the 4.3m telescope at Lowell on 2020 Jun 10, almost four years before perihelion, when it was almost 12au out from the Sun.[3] It appears to have quite a large nucleus, with estimates of the diameter ranging up to 34km,[4] although this is probably a significant overestimate and the true value is probably nearer to 20km.

The comet has been followed by amateurs since 2022 June, when it was around 21st magnitude. Throughout early 2023 it slowly brightened and by July it had reached 17th magnitude, showing a faint coma and stubby tail to the south-west.

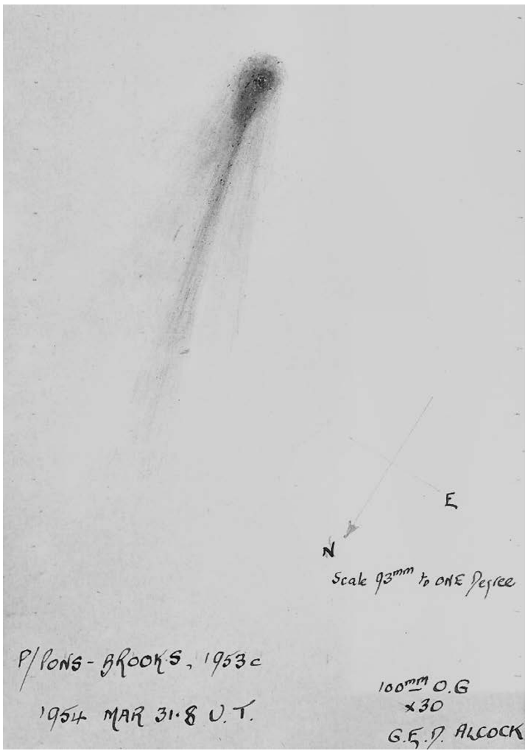
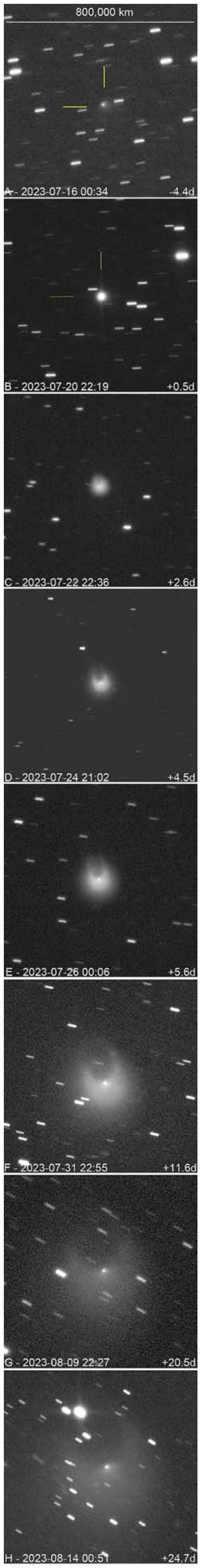


Figure 1. 1954 Mar 31.8. 0.10m OG, ×30. George Alcock, Peterborough.

The outburst

On 2023 Jul 20.82, Elek Tamás in Hungary detected a very large outburst.[5] The comet had risen from 17th magnitude to around 12th magnitude, brightening by a factor of 100 over a very short period. Early images showed an almost star-like point but gradually the new coma expanded outwards. At the time of the outburst, the comet was 3.89au from the



(A) Pre-outburst on 2023 Jul 16, 00:34 UT (Carson). Exposure 20×60s.

(B) Approximately 12 hours post-outburst; 2023 Jul 20, 22:19 UT (Carson). 20×60s.

(C) Approximately 2.6 days after the outburst; 2023 Jul 22, 22:36 UT (Alnitak). 6×120s, Johnson V.

(D) 2023 Jul 24, 21:02 UT (Alnitak). 12×60s, Johnson V.

(E) 2023 Jul 26, 00:06 UT (James). 21×60s, clear.

(F) Approximately 11.6 days after the outburst; 2023 Jul 31, 22:55 UT (Carson). 20×60s, clear.

(G) 20.5 days after the outburst; 2023 Aug 9, 22:27 UT (James). 30×60s, clear.

(H) 24.7 days after the outburst; 2023 Aug 14, 00:51 UT (Carson). 17×60s, clear.

► **Figure 2.** Sequence of images all at the same physical scale, showing expansion of the coma following the outburst. The images were obtained using three systems: Peter Carson's remote telescope at Fregenal de la Sierra, Spain (a 0.315m, *f*/8 Dall–Kirkham operating at 0.61 and 1.22 arcsec/pixel with an IMX455 CMOS sensor); the author's telescope in Chelmsford, UK (a 0.28m, *f*/10 Edge HD operating at 0.56 and 1.12 arcsec/pixel with an IMX455 CMOS sensor) and the Alnitak Observatory at Sierra del Segura, Spain (a 0.43m, *f*/6.8 PlaneWave CDK operating at 0.53 arcsec/pixel with an IMX455 CMOS sensor). The latter telescope was made available under the BAA remote observing scheme.

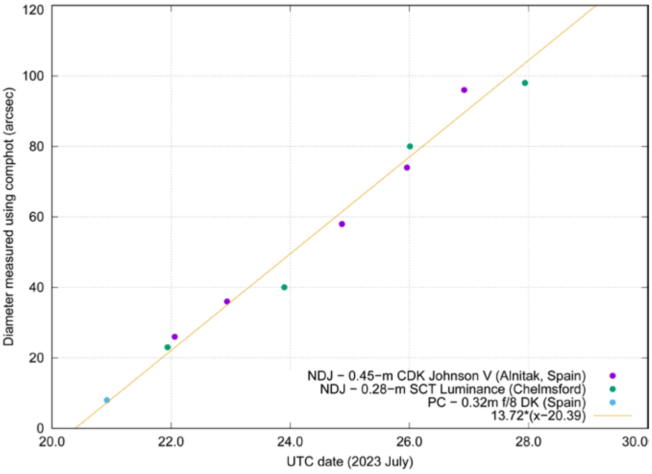


Figure 3. Plot of the coma diameter early in the outburst, showing the linear expansion rate.

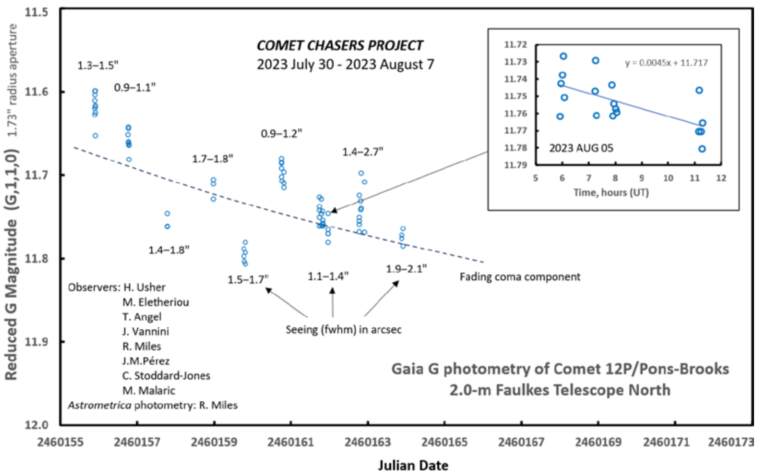


Figure 4. Plot of multi-aperture photometry obtained using a 2m telescope, showing the general coma-fading, and shorter-term variations which may be due to rotation of the nucleus.

Sun and 3.57au from Earth; an arcsecond corresponded to 2,590km projected on the sky at the distance of the object.

Post-outburst images and observations were received from many observers. The BAA observers are listed at the end of this note.

All the images in Figure 2 are presented at the same physical scale and they correspond to a view 800,000km square, projected onto the sky at the distance of the comet. Measurement of the coma diameter was done using the Section's *Comphot* software. This uses an objective approach to determine the size of the coma, which does not require human input.

Around 62 hours after the outburst, the coma had expanded and started to show interesting detail. It was teardrop-shaped, with a dark notch to the north. This notch was probably caused by blocking of the dust expansion by the nucleus, since the outburst happened over a very short time. The material rises above the nucleus and then expands spherically into a vacuum. One direction is blocked by the nucleus itself and the projection of this forms the dark lane. A similar morphology is seen in outbursts of 29P.

By 5.6 days after the outburst, the coma had expanded to a diameter of 80 arcseconds, corresponding to around 200,000km at the comet's distance. The horn structure, dark lane and the demarcation between the inner and outer coma were now much more prominent and there was some visible structure in the dark notch.

The coma continued to expand, but the total magnitude of the comet in an aperture corresponding to the coma diameter remained constant, at around 11.7. This is what would be expected if a large volume of material was suddenly injected into the coma and then expanded away. The reflective area of the dust remains constant. The magnitude only begins to fall when the photometry is no longer detecting the full extent of the coma.

The final two images in the sequence show the late stage of the outburst. The surface brightness of the inner expansion coma had faded considerably, but the dark band to the north was still prominent. By the time of the last image, 25 days after the outburst, the inner coma had expanded to a diameter of around 500,000km, almost four times that of Jupiter.

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Analysing what happened

The plot in Figure 3 shows that the coma diameter has a best-fit linear expansion rate of 13.7 arcsec/day. This corresponds to a physical expansion rate of around 200m/s. Projecting the expansion back to zero diameter indicates that the outburst occurred at 2023 Jul 20.39. Using a different approach, Richard Miles and the Comet Chasers team got an outburst time of Jul 20.45 ± 0.08, using data from metre-class telescopes in the LCOGT network, and this is nicely consistent with the results obtained using amateur instruments.

The latest observation known before the outburst was on Jul 20.08 by station A02.[6] At that time the magnitude was measured as 16.9. It appears that Tamás detected the outburst around 10 hours after it happened.

Richard Miles also performed multi-aperture photometry of the inner coma, using data from the 2m Faulkes Telescope North on Maui, collected by Comet Chasers. Their results are plotted in Figure 4 and may show evidence of the rotation of the nucleus. He writes:

> 'The variability is very evident but with observations spaced every 24 hours or so, it is difficult … to arrive at a specific period. [The absolute magnitude is] 12.3R. This was determined using multi-aperture photometry and extrapolating to zero radius. This value is 2.5 magnitudes fainter than [outbursting comet] 29P/Schwassmann–Wachmann, which has a diameter of a little over 60km, so at the same albedo 12P would be about 20km diameter.
>
> 'The amplitude of variation appears to be around 0.15–0.20 magnitudes, which equates to about 0.35–0.50mag for the bare nucleus. The inset shows a 0.025-magnitude fade over 5.5 hours of observation, so we are clearly dealing with a slow rotator of the order of 4–6 days. Since the rotational light curve is likely to be irregular in shape, we have insufficient data to identify any particular value. Only 3–4% of periodic comets outburst strongly (5mag or more) like 12P, and the hypothesis I have put forward in the literature is that such comets are almost certainly slow rotators which develop a surface crust in places of significant strength. Below this crust, cryomagma can form and [a] rupture of this crust leads to a sudden cryo-eruption, which ceases quickly as the fissure refreezes.'

At the time of writing (end of August), the faint expansion coma is still visible but very faint, and the comet has almost returned to its pre-outburst form. We expect further outbursts as this comet approaches the Sun, so please keep it under observation.

My thanks to the following BAA observers, who submitted observations of this fascinating object: Denis Buczynski, Peter Carson, Nigel Evans, Alun Halsey, Tim Haymes, Nick James, Martin Mobberley, Grant Privett, Nick Quinn, David Strange, David Swan, Peter Tickner, Bob Trevan, Mazin Younis.

References

1 *Cometography*, vol 2, pp 30–32
2 *Cometography*, vol 2, pp 521–532
3 *MPEC* 2020-M114 (**bit.ly/3LNqzGD)**
4 Recovery of returning Halley-type comet 12P/Pons–Brooks with the Lowell Discovery Telescope (**arxiv.org/abs/2007.01368)**
5 **groups.io/g/comets-ml/message/31504**
6 *MPEC* 2023-O106 (**bit.ly/469VzYX**)