Comet Section

Comet C/2022 E3 (ZTF)
lives up to expectations

Nick James
Director

The behaviour of brighter comets is often quite difficult to forecast, but C/2022 E3 (ZTF) was unusual in that it performed almost exactly as predicted. It was a nice, moderately bright object that was very well placed for those of us in the northern hemisphere, since it was near the pole at its brightest. It is rare to see a naked-eye comet this high in the sky and many observations and images were reported to the Section when the comet was at its best in early 2023. A large amount of astrometry and photometry was also performed.

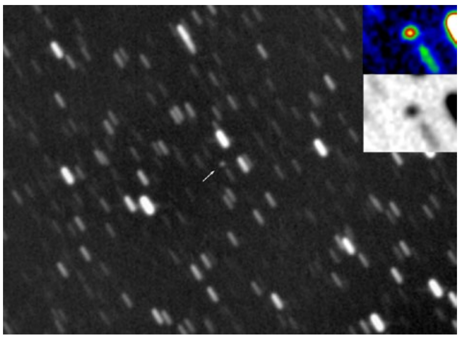


Figure 1. 2022 May 19, 11:02 UTC. 0.43m *f*/6.8 CDK, 20×60s. *(Nirmal Paul, Mayhill, New Mexico, USA)*

Top image: 2023 Jan 24, 13:42 UTC. 0.05m, *f*/5, ASI 071MC, 23×120s. 5.2×3.5°. *(Dan Bartlett, June Lake, California, USA)*

Discovery & early observations

This comet was discovered as an apparently asteroidal object on 2022 Mar 2.[1] It was detected by the Zwicky Transient Facility (ZTF) using the 1.2m, *f*/2.4 Schmidt camera at Mount Palomar. At the time of discovery, it was 4.3au from the Sun and a 17th-magnitude object in Aquila. Other observers reported cometary activity shortly after the discovery and the object was designated as C/2022 E3 (ZTF).

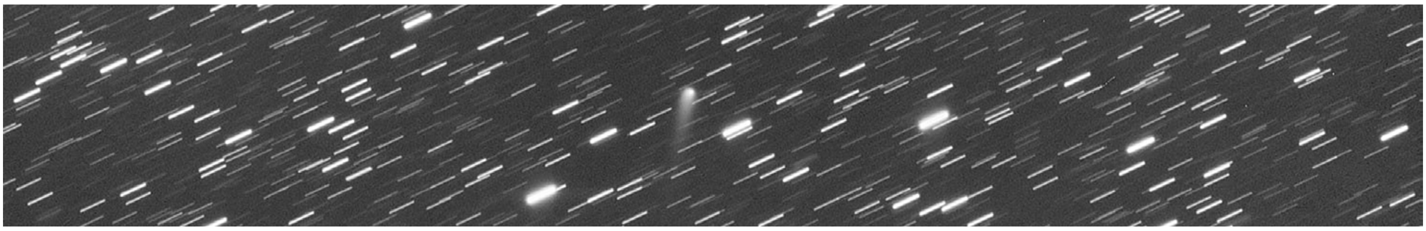
An initial orbit allowed pre-discovery observations to be found in the archives. Observations by Pan-STARRS on 2021 Jul 10 showed the comet at around magnitude 23. The initial orbit showed that it would come to perihelion on 2023 Jan 12 at a solar distance of 1.1au and that it would make a close approach to Earth on 2023 Feb 1, when it would be at a distance of only 0.28au. Early predictions suggested that the comet could reach 6th magnitude in late 2023 January.

The first image in the BAA image archive is from Nirmal Paul (Figure 1).[1] It was taken on 2022 Mar 19 and shows the comet as a faint, fuzzy object in Aquila. Images taken in April showed a short dust tail to the south-west. By June, the tail was much more prominent and had swung around to point almost due south. By July, the curved dust tail had extended to a length exceeding five arcminutes and the bright pseudo-nucleus was considerably offset in the coma (Figure 2). This was a perspective effect caused by our viewing geometry at the time. By September, the dust tail was pointing almost due east and it was recorded by many observers.

Throughout 2022 the comet brightened slowly and, if anything, it slightly overperformed; it was now expected to reach 5th magnitude at its brightest. It spent the summer moving slowly through Vulpecula, Lyra and Hercules before entering Corona Borealis in September.

By 2022 November it had reached 10th magnitude and an ion tail had formed. This type of tail is formed by ions in the coma which are accelerated away by the solar wind. Unlike the curved dust tail, they point in the anti-solar direction and are very dynamic, since they reflect the turbulence in the solar wind which is passing the comet at several hundred kilometres per second. Longer exposures tend to smear out detail in the ion tail, so the best images come from fast cameras with short exposures. The ion tail of C/2022 E3 became bright enough to be imaged by many observers. Its low surface brightness meant that it was a challenge for visual observers, but it was reported by those observing under very good conditions.

Towards the end of November, the best time for observing the comet moved from the evening to the morning, as it continued to move slowly northwards in Corona Borealis. During the Moon-free period at the end of November, observers in dark-sky locations were recording an ion tail exceeding 1° in length. By mid-December, with the comet at 9th magnitude, the ion tail was showing a great deal of detail in images submitted by multiple observers (Figure 3). A large dust fan was visible between the dust tail



▲ **Figure 2.** 2022 Jul 4, 01:17 UTC. 0.32m *f*/8 CDK, QHY600, 20×60s. *(Peter Carson, Fregenal de la Sierra, Spain)*

and the ion tail. This was caused by dust in the comet's orbital plane projected onto the sky in the direction of the comet.

A naked-eye comet

The viewing geometry changed rapidly as the comet came to perihelion and approached Earth. By early 2023 January, it was a naked-eye object from dark sites and a fine visual object in binoculars. The ion tail was very active throughout 2022 December and 2023 January (Figure 4) and several disconnection events (DEs) were observed. An ion tail DE can occur when the comet's ionosphere encounters a change in polarity of the heliospheric magnetic field, as it is dragged outwards from the Sun with the solar wind. This rips the ion tail from the coma and pushes it downstream. A significant DE occurred on the morning of 2023 Jan 19 (Figure 5) and was reported by many observers. Images showed the old ion tail drifting away from the coma, with a highly collimated new tail forming in the gap.

By late January, the comet was moving rapidly under the pole and showed a lot of detail to visual observers (Figure 6). Spectra taken in January showed strong C_2 Swan Band emission

Figure 3. 2022 Dec 31, 06:04 UTC. 0.32m *f*/8 CDK, QHY600, 2×26×60s. *(Peter Carson, Fregenal de la Sierra, Spain)*

from the coma, consistent with its green colour in images. The comet also showed intense CN emission in the near ultraviolet at around 380nm, but most imaging systems did not record this (Figure 7).

Earth crossed the comet's orbital plane on the morning of 2023 Jan 23 at 02h UT. Since the grains which form the dust tail are relatively massive, they stay in the orbital plane of the comet. When we cross this plane we see the dust edge-on. The curved dust tail can then extend behind the comet and be seen as a forward-pointing anti-tail. The most famous example of this was comet C/1956 R1 (Arend–Roland) in 1957, but a number of comets have shown this effect more recently. Images of the comet taken around Jan 23 show an almost three-dimensional effect, as we see the recently released dust in front of the spherical, green coma and the older dust behind it (Figure 8). Deep images showed the long dust anti-tail (Figure 9).

'It will never be observable from the UK again'

By the last week of January, as the comet reached its brightest, the Moon was becoming more of a problem. First quarter was on Jan 28. Despite the bright moonlight, the comet was well seen since it was at its brightest and near the zenith. Many impressive images and ►

▼ **Figure 4.** 2023 Jan 15, 05:00 UTC. 0.10m ASI 294MC, 80×120s. 1.8×1.0°. The ion tail extends out of the field of view in this image. *(Mazin Younis, Morocco)*

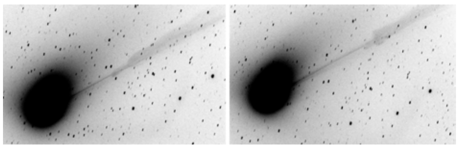


Figure 5. 2023 Jan 19, 03:46 (left) and 04:57 (right) UT. 0.28m *f*/10 SCT, ASI 6200MM, 5×60s. Two images taken 70 minutes apart, showing the ion tail disconnection event. *(Nick James, Chelmsford)*

▶ drawings were submitted to the Comet Section around this time, which are recorded in the online Section archive and the BAA image gallery (Figure 10 and the top image on p.78).

On the evening of 2023 Feb 6, it passed within 0.5° of a much fainter comet, C/2022 U2 (ATLAS). At the time, C/2022 E3 was around magnitude 5.5 and C/2022 U2 was about magnitude 13. During February, C/2022 E3 faded from 5th to 8th magnitude as it moved south through Auriga and Taurus. It crossed the celestial equator in early 2023 March and will end 2023 as a 17th-magnitude object in the far southern constellation of Reticulum.

The orbit

The comet's incoming orbit showed an eccentricity relative to the solar-system barycentre of slightly less than one, implying that it was not a new visitor to the inner solar system. Its last perihelion was around 50,000 years ago. Gravitational perturbations during its pass through the inner solar system have changed the eccentricity to slightly greater than one on the outbound path, so it looks as if this was the comet's last visit to the solar neighbourhood and it will now depart the solar system, heading off into interstellar space to possibly visit another star system in the future. This, combined with its highly inclined orbit, means that it will never be observable from the UK again.

The light curve shown in Figure 14 (opposite page) is from the Comet Observation (COBS) database.[3] It includes estimates from the following BAA observers: Peter Carson, Mike Collins, Kevin Hills, Nick James, Denis Buczynski, Mark Phillips, David Swan and James Fraser. Many of these estimates were made electronically using the Section's *Comphot* software. The comet was very well behaved and reached a maximum total magnitude of around 5.0 at the time of closest approach on 2023 Feb 1. The best-fit magnitude curve is:

$$m_1 = 7.1 + 10.2\ \log_{10}(r) + 5\ \log_{10}(\Delta)$$

where r and Δ are the distances from the Sun and Earth in astronomical units. The nucleus was small, probably less than a kilometre in diameter, and the rotation period derived from features in the coma was around 8.7 hours.[4]

1 *CBET* 5111 (2022)
2 **bit.ly/3YQLP1F**
3 **cobs.si**
4 **bit.ly/3loDNzh**

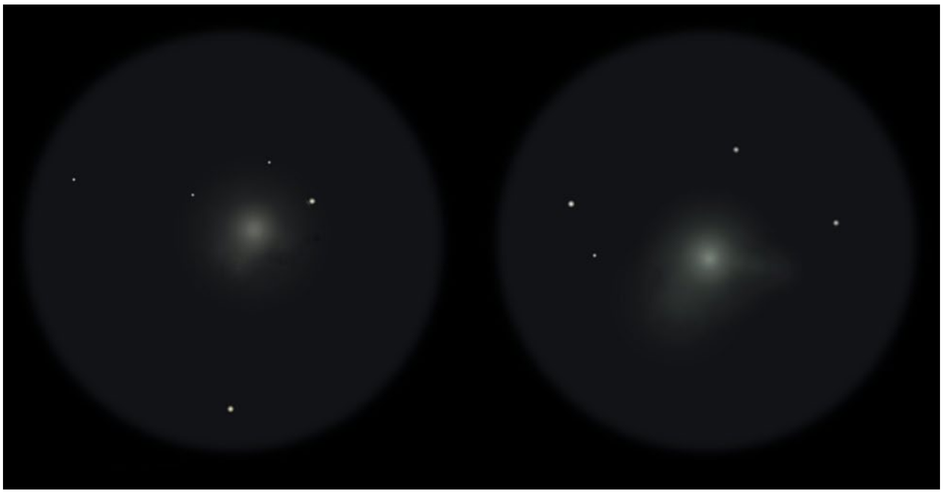


Figure 6. 2023 Jan 20, 01:46–02:12 UT. 0.31m Newtonian; ×38 (left) & ×115 (right). *(Paul Abel, Leicester)*

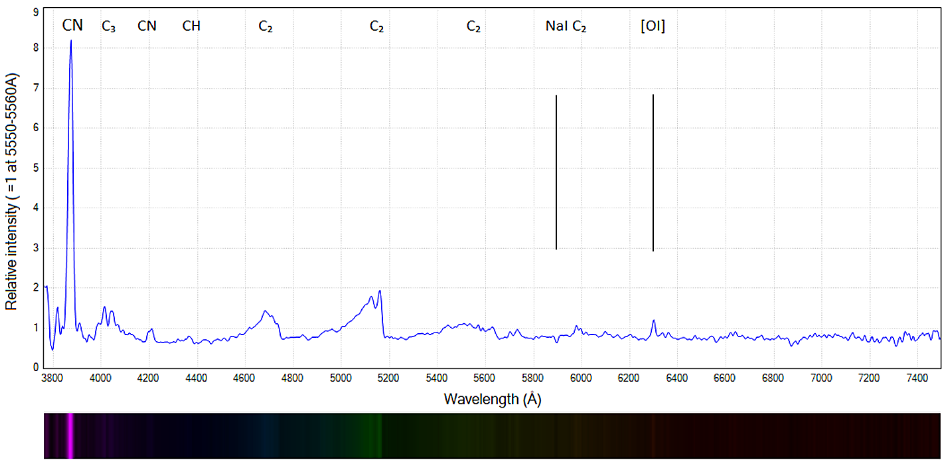


Figure 7. 2023 Jan 21, 01:30 UTC. 0.20m *f*/6.3 SCT, Alpy 600 spectroscope, ATIK 314L, 5×600s. Plotted using *BASS Project 1.9.9. (Hugh Allen, Wells, Somerset)*

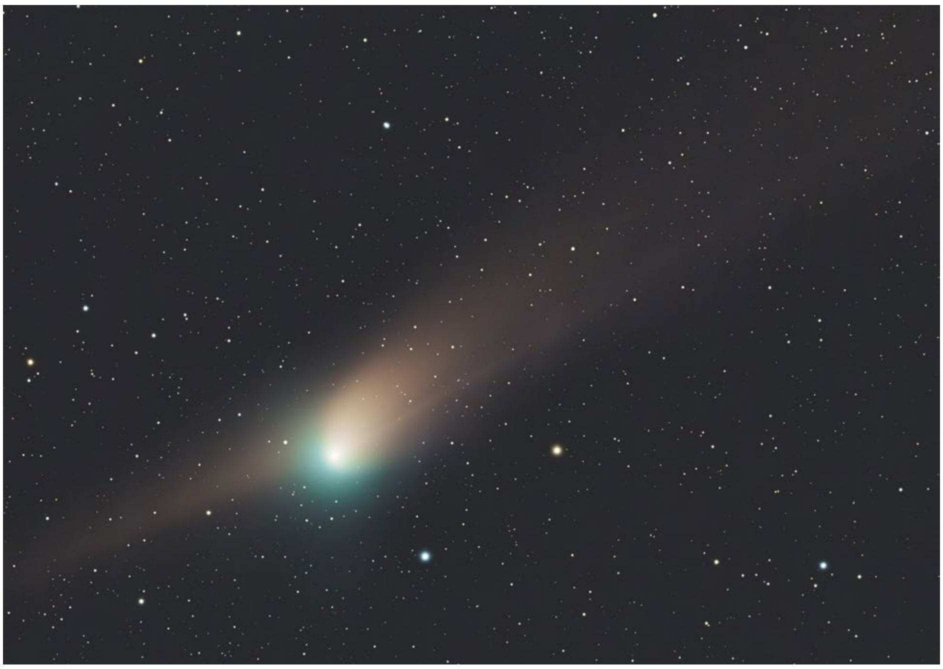
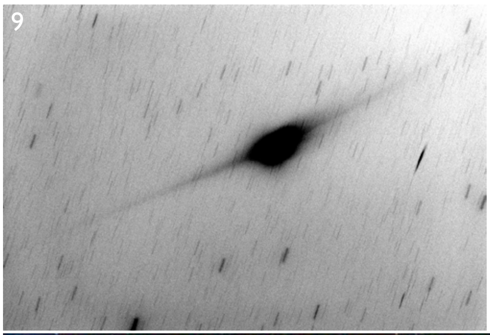


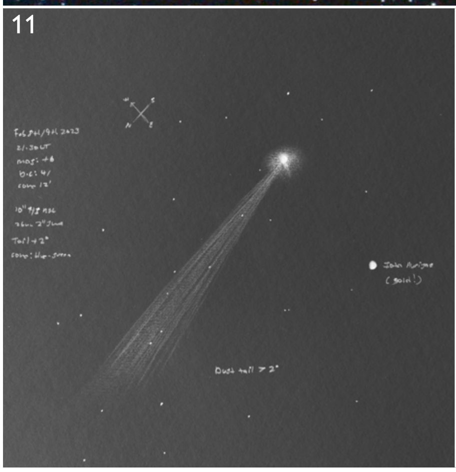
Figure 8. 2023 Jan 22, 02:30 UT. 0.09m, ASI 294MC, 100×90s. 1.9×1.3°. This image shows the comet on the day before the plane crossing, with the green coma, broad dust tail to the right and anti-tail to the left. *(Callum Wingrove, Stanmore)*

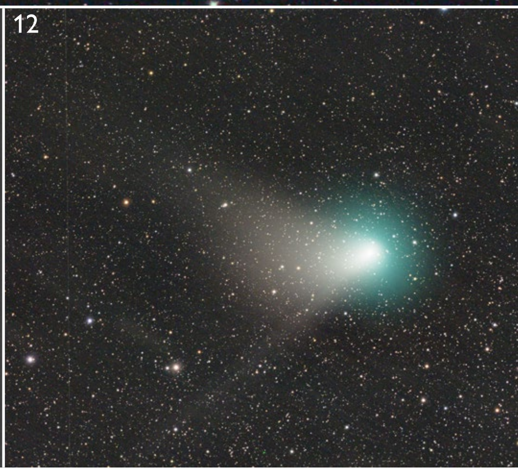


Observers

My thanks to the following observers who submitted astrometry, images, visual observations, spectra, and magnitude estimates to the Section.

Paul Abel, Hugh Allen, Dean Ashton, Owen Brazell, Denis Buczynski, Peter Carson, Marc Charron, Martin Crow, David Davies, Simon Dawes, Gary Eason, Nigel Evans, Mark Fairfax, Mike Glenny, Duncan Hale-Sutton, Carl Hansen, Mike Harlow, Tim Haymes, Nick Hewitt, Nick James, Steve Knight, Robin Leadbeater, Martina McGovern, Martin McKenna, Martin Mobberley, Brian O'Halloran, Andrew Paterson, Callum Potter, Gary Poyner, Alex Pratt, Grant Privett, Adam Rawlinson, Andrew Robertson, Jonathan Shanklin, Ian Sharp, David Strange, David Swan, Charles Taylor, Graham Taylor, Alan Thomas, Peter Tickner, Alan Tough, Ivan Walton, James Weightman, Paul Whitmarsh, Callum Wingrove and Mazin Younis.





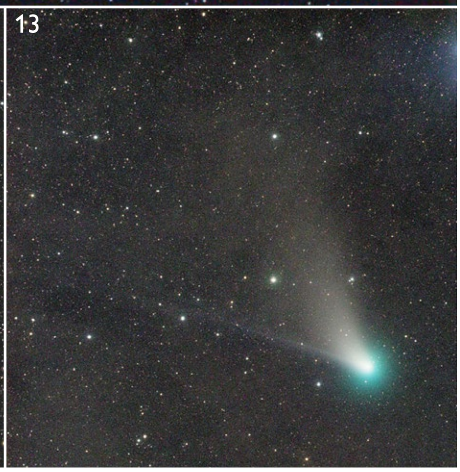


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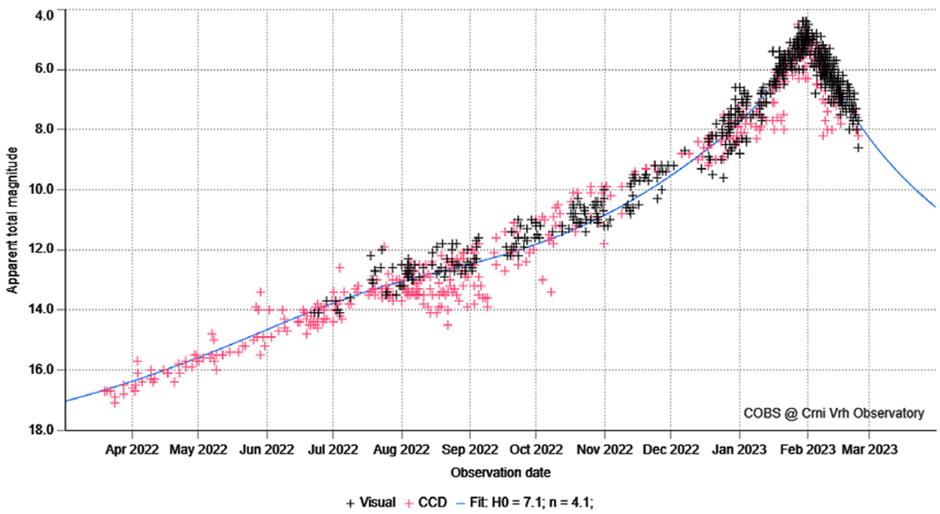
Figure 9. 2023 Jan 23, 01:40 UT. 0.07m, *f*/5, ASI 294MC, 24×120s. 3.2×2.2°. A deep negative image at the time of orbital plane crossing, showing the dust anti-tail to the left with the broad dust tail and narrow ion tail to the right. *(Nick James, Chelmsford)*

Figure 10. 2023 Jan 28, 03:05 UTC. 0.16m, *f*/3.3, Sony A7s, 30×30s. 2.5×1.0°. *(Denis Buczynski, Tarbatness)*

Figure 11. 2023 Feb 8, 21:40 UTC. 0.25m, *f*/5; 26mm SWA eyepiece. A 2° dust tail was visible. *(Martin McKenna, Co. Tyrone)*

Figure 12. 2023 Feb 9, 19:51 UTC. 0.10m, ASI 294MC, 48×60s, 1.3×1.2°. This shows the green coma and the broad dust fan well. The ion tail is also visible to the lower left. *(Mazin Younis, Morocco)*

Figure 13. 2023 Feb 16, 02:53 UTC. 0.11m, *f*/5, STL-11000M; LRGB 180:120:120:120s. 2.1×2.2°. *(Martin Mobberley, Utah, USA)*



RIGHT: **Figure 14.** Light curve from COBS.