# A great display from comet C/2021 A1 (Leonard)

The first comet to be discovered in 2021 was found by Catalina Sky Survey observer Gregory Leonard on January 3. He was using the 1.5-m Mt. Lemmon survey telescope and he reported the comet as a 19th magnitude object in Canes Venatici with an apparent 10 arcsecond diameter coma and 5 arcseond tail[[1]](#endnote-1). At the time comet C/2021 A1 (Leonard) was just over 5 au from the Sun. Numerous pre-discovery images were found in the PanSTARRS archive going back to 2020 April 30 but the earliest astrometry was from Mt. Lemmon on 2020 April 11 when the comet was magnitude 21.8[[2]](#endnote-2). The pre-discovery astrometry allowed a precise orbit to be computed very quickly. This indicated that the comet would come to perihelion 2022 January 3 at a distance of 0.62 au and that it would pass within 0.24 au of Earth on 2021 December 12 and within 0.029 au of Venus on 2021 December 18.

The inbound orbit had a 1/a value of +0.00057 corresponding to an original period of around 75,000 years. The relatively small perihelion distance and the fact that it was not a first-time visitor to the inner Solar System suggested that the comet could become a naked-eye object in 2021 December although at the time this was very uncertain. The geometry of its orbit favoured a strong enhancement of the brightness due to forward scattering on the days around 2021 December 14 although the extent of this brightening would depend on the amount of dust in the comet’s coma and tail. The best views would be from the southern hemisphere as the comet would be significantly south of the celestial equator when at its brightest.

The first observation received by the BAA was made by Denis Buczynski (Tarbatness) on the morning of 2021 January 6 when the comet was still on the MPC’s Possible Comet Confirmation Page[[3]](#endnote-3) as object C4AGJ62. The comet brightened slowly through most of 2021 and remained at a high northern declination moving slowly through Canes Venatici (CVn) then Ursa Major (UMa) and then back into CVn. Through this period observations were received from Denis, Peter Carson, David Swan, David Hardwick, Tony Angel, Richard Sargent and David Strange.

By the start of 2021 October the comet had reached 13th magnitude and was 1.8 au from the Sun and 2.4 au from the Earth and it was beginning to show quite a nice tail to the north in telescopic images. The comet brightened rapidly during October as it got closer to the Sun and Earth, reaching 10th magnitude by early November with the comet well-placed in the morning sky. Colour images from Martin Mobberley and Mazin Younis showed a strong, green coma with a gas tail pointing to the northwest. By November 15 the gas tail was around 2° long as measured by imagers at dark sites.

On November 24 the comet passed near to two prominent galaxies, NGC4631 and NGC4656, the Whale and Crowbar, and several imagers captured this event at different scales. The comet was now bright enough for spectroscopists to get good results. On 2021 November 25 Robin Leadbeater obtained a spectrum using an ALPY 200 which showed prominent Swan Band emission lines out to around 2 arcminutes from the photocentre.

The comet was now showing significant structure in the inner coma and, towards the end of November, there was some speculation that the nucleus was breaking up. At this time the apparent motion of the comet was quite large and so the bright central region was elongated in long exposures. Short exposure, high-resolution images showed no evidence of disruption and there was no sign of any significant biases in astrometry submitted to the section.

On the morning of 2021 December 3 the comet had a close approach to the globular cluster M3. Unfortunately, the weather over much of the UK was poor but excellent images of the conjunction were received from Ian Sharp (Spain), Peter Gudgeon (Spain), Martin Mobberley (New Mexico) and Mazin Younis (Morocco). From the UK, Andrew Robertson (Norfolk) managed to get a visual view of M3 and the comet using 7x50 binoculars as the sky cleared just before dawn. In a 0.30-m, f/12 Mewlon he commented that M3 was more concentrated and slightly brighter than the comet’s coma.

The comet was now moving rapidly south through Bootes and images from Tim Haymes, Martina McGovern, Michael Buechner, James Weightmann, Peter Tickner and Manolo Rodriguez showed the lengthening tail. From UK latitudes the comet was diving into the morning twilight and the last UK observations submitted to the BAA were obtained on the morning of December 11. The comet was only 11° up at the start of astronomical twilight but the weather favoured the eastern side of the country and both Peter Carson and myself managed to obtain images using portable equipment at two different locations in Essex. At this time the comet was 0.79 au from the Sun, 0.24 au from the Earth and around 5th magnitude.

After the comet had disappeared from UK skies it started to brighten rapidly. Mike Olason (Arizona) reported the first of a series of small outbursts on December 14. The outburst appears to have increased the amount of dust in the coma and enhanced the effect of the predicted forward scattering. The overall effect was to boost the comet’s magnitude to around +3 for a short period. Images from the SECCHI/HI-2 camera on STEREO-A taken on 2021 December 14 confirmed the increase in activity since it was not affected by the forward scattering[[4]](#endnote-4). A further small outburst appears to have taken place on December 17 but by then the comet was fading rapidly as the forward scattering became less significant.

The outbursts led to a significant increase in gas production from the nucleus and this led to a dramatic change in the comet’s tail. Images from December 18 onwards show a rapidly developing ion tail and exquisite detail both in the inner coma and in the tail itself. At this time the comet was 0.30 au from the Earth but only 0.03 au from Venus. It would have been a stunning sight for any Venusians who were lucky enough to have a break in their sulphuric acid clouds and they may also have experienced a spectacular meteor shower two days later as Venus passed through the tail of the comet[[5]](#endnote-5).

Considerable detail was visible in the coma. Images from Terry Evans (South Australia) show jet features in the inner coma extending into the tail. At this time the length of the gas tail was increasing rapidly. On December 22.5 Rob Kaufman (Victoria, Australia) reported a tail length from his images which exceeded 13° with a prominent disconnection event around 5° from the coma. Other imagers from very dark sites reported even longer tail lengths.

In late December the best images were coming from robotic telescopes at dark sites in the southern hemisphere, particularly Namibia. The tail structure continued to evolve over the Christmas period and it was recorded in some stunning images. One of the most detailed images was taken by Gerald Rhemann on 2021 December 27 using a fast astrograph from Namibia. Alan Tough also managed to capture this detail using in a remote telescope in Namibia. The development of the tail over multiple nights is well shown in the sequence of images in the BAA’s image archive[[6]](#endnote-6) and, the tail continued to develop as the year drew to a close with Peter Goodhew’s image showing the situation on December 31.

The comet was now fading having reached a peak magnitude around +3 around the middle of December. Perihelion was on 2022 January 3 and there was a small outburst around January 8. By then the comet was dropping below naked eye visibility as it moved away from the Earth and the Sun. The last image in the BAA archive at the time of writing is by Kaufman on 2022 February 2.4. By that time the comet had faded back below 10th magnitude.

With the exception of the period around the outbursts and forward scattering in mid-December the comet’s lightcurve was very well behaved. Jonathan Shanklin derives the following magnitude parameters from observations submitted to the section:

H10 = 8.14 ±0.05, k = 11.74 ±0.20

The following observers contributed to this lightcurve: Jose Aguiar, Denis Buczynski, Peter Carson, Mike Collins, Kevin Hills, Nick James, Michael Mattiazzo, Yoshimi Nagai, Giuseppe Pappa, Johan Warell and Christopher Wyatt.

The comet’s orbit was changed by gravitational perturbation as it moved through the inner Solar system and the outbound path was slightly hyperbolic. Having last visited the inner Solar System around 75,000 years ago this comet will never return. We were lucky to have been here for its final show in this star system!

## Figure captions

**2021a1\_20210106\_0104\_dgb.jpg -** 2021 January 6, 01:04 UTC. 0.36-m f/6 SCT, ASI1600MM, 20x120s. Denis Buczynski, Tarbatness.

**2021a1\_20211005\_0504\_pcarson.jpg -** 2021 October 5, 05:04 UTC. 0.31-m f/8 Dall Kirkham, QHY600, 20x60s, Peter Carson, Freqgenal de la Sierra, Spain.

**2021a1\_20211109\_1140\_mpm.jpg -** 2021 November 9, 11:40 UTC. 0.51-m f/4.5 CDK, FLI-PL11002M, LRGB 300,120,120,120s, Martin Mobberley, New Mexico.

**2021a1\_20211125\_054113\_ndj.jpg -** 2021 November 25 05:41. 0.28-m f/10 EdgeHD, ASI6200MM, 21x60s, Nick James, Chelmsford

**2021a1\_20211125\_rleadbeater.jpg -** 2021 November 25, 02:25 UTC. 0.28-m f/5.5 SCT, ATK314, ALPY 200, 3x600s, Robin Leadbeater, Cumbria

**2021a1\_20211203\_0506\_ids.jpg -** 2021 December 3, 05:06 UTC. 0.10-m, f/6.25 APO, Trius Pro 694, L: 6x120s, R,G,B: 180s each, Ian Sharp, Andalucia, Spain.

**2021a1\_20211203\_0600\_mazin.jpg -** 2021 December 3, 06:00 UTC. 0.10-m, f/5.5 ED, ASI294MC, 15x60s, Mazin Younis, Adar, Morocco.

**2021a1\_20211207\_0400\_mcgovern.jpg -** 2021 December 7, 04:00 UTC. 0.10-m, f/5.8 APO, ASI294MC, 23x120s, Martina McGovern, Cambridge

**2021a1\_20211209\_0602\_tickner.jpg -** 2021 December 9 06:02 UTC. 0.36-m, f/10 SCT, ASI071MC, 160x8s, Peter Tickner, Berkshire

**2021a1\_20211211\_0549\_pcarson.jpg -** 2021 December 11, 05:49 UTC. 100mm FL, f/2, EOS 60Da, 5x30s, Peter Carson, Paglesham, Essex.

**2021a1\_20211215\_0128\_molason.jpg -**2021 December 15, 01:28 UTC. 50mm FL, f/3.5, ST-402ME, Mike Olason, Arizona.

**2021a1\_20211218\_grhemann.jpg -** 2021 December 18, 18:41 UTC. 0.30-m, f/3.6, ASI6200MM, LRGB: 30s each, Gerald Rhemann, Farm Tivoli, Namibia.

**2021a1\_20211221\_1036\_evans.jpg -** 2021 December 20, 11:17 UTC. 0.20-m, f/8.8 APO, SX-694, 10x60s, Moorook, South Australia.

**2021a1\_20211227\_actough.jpg -** 2021 December 27, 19:00 UTC, 0.20-m, f/3 RH astrograph, QHY600M, 2x80s, Alan Tough, Hakos, Namibia.

**2021a1\_20211227\_grhemann.jpg -**2021 December 27, 19:00 UTC, 0.30-m, f/3.6, ASI6200MM, LRGB: 120s each, Gerald Rhemann, Farm Tivoli, Namibia.

**2021a1\_20212131\_1033\_goodhew.jpg -** 2021 December 31, 10:33 UTC, 0.106-m, f/5 Petzval, FLI-PL16803, 24x60s LRGB, Peter Goodhew, NSW, Australia.

**2021a1\_20220109\_1125\_mattiazzo.jpg -** 2022 January 9, 11:25 UTC. 0.28m, f/2.2 RASA, EOS 6D. 300s, Mike Mattiazzo, Victoria, Australia.

1. CBET 4907 [↑](#endnote-ref-1)
2. MPEC 2021-A99 [↑](#endnote-ref-2)
3. https://minorplanetcenter.net/iau/NEO/pccp\_tabular.html [↑](#endnote-ref-3)
4. https://stereo.gsfc.nasa.gov/news/cometleonard.shtml [↑](#endnote-ref-4)
5. https://arxiv.org/abs/2107.12370 [↑](#endnote-ref-5)
6. https://britastro.org/cometobs/2021a1/thumbnails.html [↑](#endnote-ref-6)