Comet Section

The fragmentation of C/2019 Y_4 (ATLAS)

Nick James
Director

The comet C/2019 Y4 was discovered by the Asteroid Terrestrial-impact Last Alert System (ATLAS) on 2019 Dec 28 using a 0.50m Wright–Schmidt telescope on Mauna Loa, Hawaii. ATLAS uses two such telescopes to obtain high-cadence, wide-field images of the sky. It is designed to find small incoming objects in the last few days before impacting Earth, but it is also very good at finding comets.

Shortly after discovery, the orbit was computed and this showed that the comet would reach perihelion on 2020 May 31 at a distance, q, of only 0.25au from the Sun. The current period is around 5,500 years and the German comet observer Maik Meyer pointed out that the orbit is very similar to that of the Great Comet of 1844 (C/1844 Y1). It appears that C/2019 Y4 and C/1844 Y1 are both fragments of a larger parent body which may have broken up at the previous perihelion 5,100 years ago,[1] although fragmentations are also possible far from perihelion.

Figure 1. An image of C/2019 Y4 taken on 2020 Mar 20, using a 0.51m PlaneWave and FLI-PL11002M CCD in New Mexico, USA. The field of view is approximately 0.5° across. *Martin Mobberley*

Fragmenting comet nuclei are relatively common. We know that, historically, all of the ▶

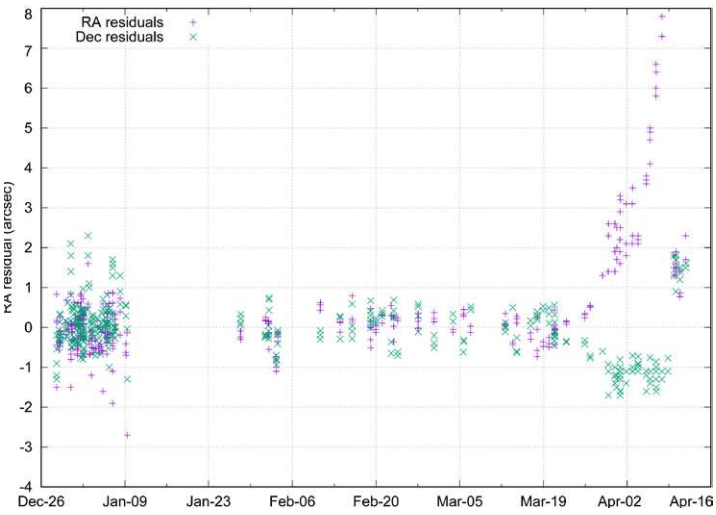

Figure 2. Astrometric residuals for C/2019 Y4 showing the gradual divergence after Mar 25. The residuals after Apr 9 show one of the fragments (component A).

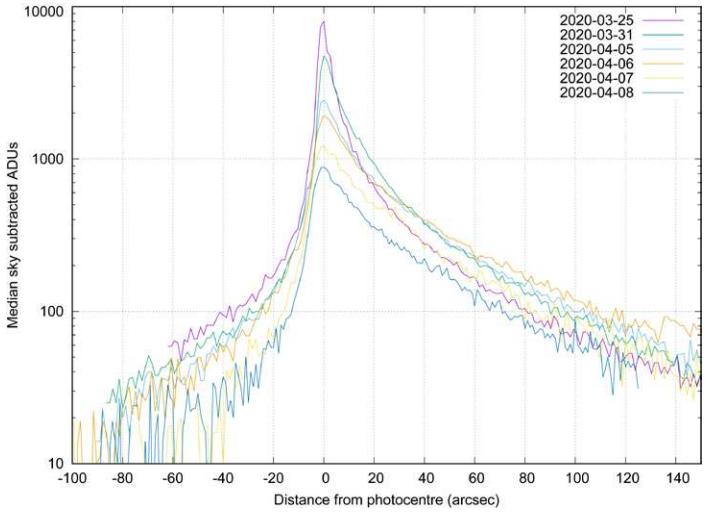

Figure 3. Evolution of the brightness profile of the coma (positive offset corresponds to the tail direction) from Mar 25 to Apr 8.

▶ H-alpha

Prominences

24 observers reported a prominence MDF of 1.42 for March.

Few prominences of note were recorded during March, with most being confined to the second half of the month.

On Mar 1 an unconnected arch prominence was seen near the SW limb, rising to a height of around 40,000km and stretching around the limb for approximately 100,000km. On Mar 2 at 10:06 UT, a rapid extension and reduction was observed in an arch prominence on the SW limb for about 20 minutes; it achieved about 27,000km in height at its peak.

A faint pillar prominence rising to about 50,000km was seen on the NE limb on Mar 9. A prominence hearth consisting of three small tree-like prominences was on the NW limb on Mar 11, with a height of about 40,000km and width of 50,000km. On Mar 17 a very small but quite strong prominence was noted on the NW limb at high latitude.

An arrow-shaped prominence was on the SW limb on Mar 23, rising to about 50,000km. A cloud of plasma was also seen off the NW limb. On Mar 25, two plasma clouds were observed off the SW limb with a thin strand of material connecting the two. The feature was about 50,000km in height, with a width of around 60,000km.

A prominence on the NE limb seemed to be connected to an active region forming there on Mar 28. On Mar 29 a small arch-shaped prominence was on the E limb.

On Mar 30 a small pyramid-type prominence was on the NW limb and two further small prominences were noted on the SE limb; one a pillar and the other, further south, a pyramid. Large spike prominences were reported on the NE and SW limbs on Mar 31.

Bipolar magnetic regions, filaments & plage

20 observers reported a filament MDF of 0.46 and 17 observers reported a plage MDF of 0.22 for March.

On Mar 2 a filament measuring around 90,000km in length was reported in the NE quadrant, near to the limb. Plage was seen with AR2758 on Mar 8 & 9. A small filament was seen near the W limb on Mar 22, and another small filament was recorded on Mar 23.

CaK

CaK plage was present Mar 11–16 at approximately S34°/232°; further CaK 'hot spots' were seen scattered over the disc during the month.

CaK MDF 0.73 for March.

Flares

No flares were reported during March.

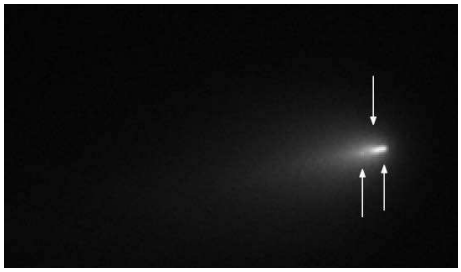

Figure 4. 2020 Apr 6, 21:29–23:36 UT. 0.30m *f*/5 Newtonian with ASI1600MM-C camera in Southampton, UK. Baader 610nm longpass filter; 682×10s subframes. *Nick Haigh*

▶ members of the Kreutz sungrazer group came from the same parent body. We have observed a number of fragmentation events, most notably the break-up of D/1993 F2 (Shoemaker–Levy) prior to its impact on Jupiter in 1993 and, more recently, the cascading fragmentation of 73P/Schwassmann–Wachmann at its returns in 2006 and 2017.

Comet nuclei are generally rather weak agglomerations of ices and refractory materials. Tidal, thermal and rotational stresses can overwhelm their gravitational and structural binding forces causing fragmentation to occur. The fragmentation can be survivable, as in the case of 73P, or catastrophic, as in the case of C/2012 S1 (ISON) which was ripped apart by tidal forces at perihelion in 2013 November, leaving only a dissipating trail of dust.

It is thought that most fragmentations are benign events which give rise to the components separating at rather low relative velocities (a few metres per second). Active surfaces on the sunward side of the fragments then produce rocket forces (non-gravitational forces or NGFs) that accelerate the low-mass fragments away from the remaining nucleus approximately along the Solar radius vector, *i.e.* in the general direction of the tail.

During February and early March, C/2019 Y4 brightened rapidly and hopes were raised that this could become a very nice object in the evening twilight around the end of May. Certainly in March it was a good target in wide-field, fast imaging systems (Figure 1). Indeed I used the first ever BAA webinar to discuss the prospects for the object, giving a range of scenarios – none of which included the possibility that this fragment of a comet would fragment again.

The fragmentation unfolds

The first indication that something was happening to the nucleus was that the magnitude of the central part of the coma began to stagnate. This was reported by Denis Buczynski on Mar 19 (private email) and by the Spanish Cometas-Obs group.

At around the same time the astrometric residuals (*i.e.* the difference between the observed and predicted positions) began to grow, as shown in Figure 2. This plot shows the astrometric residuals in RA and Dec., using an orbit prediction based on all the astrometry up to Mar 25 and computed using Bill Gray's *FindOrb*. It can be seen that the RA residual increases rapidly through the last part of March. The direction of this error was in the position angle (PA) of the tail.

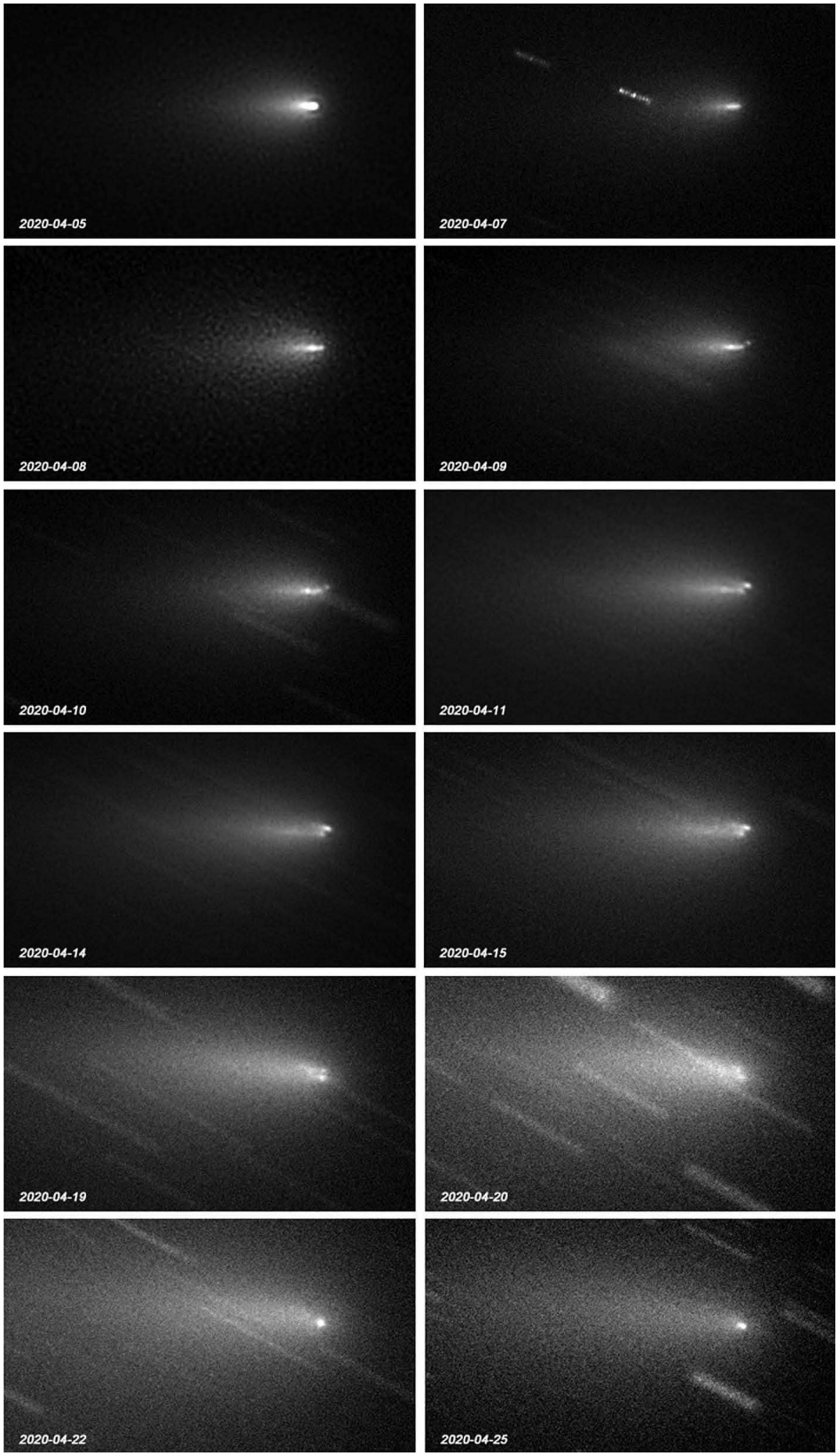

Figure 5. Images of the central part of the comet's coma, processed in the same way for 12 nights from 2020 Apr 5–25 in Chelmsford, UK. Images were generally taken around 21–22:00 UTC. The field of view is 3.8×2.2arcmin. 0.28m *f*/10 SCT and KAF-6303 CCD. *Nick James*

What we were seeing was the fragmentation occurring, with large amounts of material moving down the tail, but at scales below the resolution of our imaging systems. As a result ▶

Launch of a new weekly BAA webinar

Philip Jennings
Editor

April saw the debut of a new type of BAA event, as participants in homes across the UK and beyond settled down to join the Association's first webinar.

In response to the astronomy event calendar being rapidly emptied by cancellations in the wake of the COVID-19 pandemic, the webinars have emerged as a weekly fixture which anyone can take part in. Masterminded and hosted by Andy Wilson, these are held using the Zoom online meeting platform at 19:00 BST each Wednesday. They can be joined *via* the instructions given at **britastro.org/wedwebinars**, or viewed on the BAA YouTube channel (see link in box at right) where they are broadcast live. Each comprises a talk of approximately 30 minutes, followed by a Q&A session with the speaker, sometimes joined by guest panelists.

The first, on observing prospects for the then-brightening comet C/2019 Y4 (ATLAS), was held on Apr 1. (Appropriately enough, the comet duly transpired to be pulling a prank on us all since it then promptly disintegrated; see preceding article.) Comet Section Director Nick James' presentation, in which he prophetically reminded us to expect the unexpected, was watched live by some 218 viewers.

The new possibilities of this technology have been embraced by the Equipment & Techniques Section Director, Dr David Arditti, who has given observing demonstrations live from his observatory in Edgware. Also in April, Variable Star Section Director Dr Jeremy Shears profiled two enigmatic variable stars of the spring sky, R and T Coronae Borealis. Dr John Mason gave a two-part webinar on the early life of his late friend Sir Patrick Moore, complete with interjections from the man himself *via* extracts from his contemporaneous notebooks. At the time of going to press, special webinars were also planned in lieu of cancelled BAA meetings.

More webinars are scheduled (see back cover). To further support astronomers during lockdown, new instructional videos have also been added to the YouTube channel and on Mar 23, the full video archive of meetings since 2008 was made available for all to view at **britastro.org/video**.

BAA webinars, 2020 April–May

Visit **youtube.com/user/britishastronomical** for full recordings of these and subsequent events

Apr 1: 'Prospects for C/2019 Y4 (ATLAS)' by Nick James

Apr 8: 'Venus live' by Dr David Arditti

Apr 15: 'Sir Patrick Moore – early life, mentors and notebooks (Part I)' by Dr John Mason

Apr 22: 'Two variable stars in the Northern Crown' by Dr Jeremy Shears

Apr 24: 'A special image for the 30th anniversary of the launch of the *Hubble Space Telescope*' by Dr John Mason

Apr 25: Spring Meeting – 'Is anybody out there?' by Prof Simon Goodwin, followed by 'Exoplanet division update on pro-am projects' by Roger Dymock

Apr 29: 'Twilight tour of the Moon' by Dr David Arditti

May 6: 'From kitchens to comets – Hunting for molecules with a spectroscope' by Hugh Allen

May 13: 'Sir Patrick Moore – Early life, mentors & notebooks (Part II)' by Dr John Mason

May 20: 'The Solar Cycle' by Lyn Smith

May 27: Meeting – 'The BAA in Suffolk between the World Wars' by Bill Barton, followed with 'Sky notes' by Nick James

▶ the astrometry was biased tailward. This is also shown in the brightness profile of a slice through the brightest part of the comet, parallel with the tail (Figure 3). This figure shows the evolution of this profile from Mar 25 through to Apr 8. The peak brightness of the coma dropped by a factor of 10 over this time and it became much broader.

By Apr 6, the components of the fragmentation had separated sufficiently that they could be resolved in high-resolution images. The first amateur imager to show details of the break-up that I am aware of was Nick Haigh, from Southampton. Nick used techniques usually applied by planetary imagers (stacking a very large number of short exposures and using iterative sharpening techniques in post-processing) to produce images of very high quality. His image of Apr 6.9 shows three components.

Over subsequent days, a combination of very good UK weather, the COVID-19 lockdown and the fact that the comet was near the zenith meant that observers had an opportunity to image the fragmentation on most nights in good seeing conditions. Images showing the resolved fragments were received from Haigh, Tickner, Buczynski, Miles, Birtwhistle and others.

My sequence from Apr 5–25 shows the evolution of the various components over that time (Figure 5). Of note is the sudden appearance of a fragment to the NW (ahead and above), the extended coma on Apr 9 and its subsequent drift down the tail. This fragment could be tracked for at least 12 days.

Once the components had separated sufficiently, it was possible to perform astrometry on them. Various groups adopted different nomenclatures for the components, which made combining astrometry difficult. Within the BAA we used the designations marked on the Faulkes image shown in Figure 6. Astrometry of the components post-break-up was received from Buczynski, Miles, Birtwhistle, Storey, Hawley, Pratt and Mickleburgh. The astrometry of the individual components was used by the Minor Planet Center to produce orbits for the four main ones (A–D) but, by the time the *Minor Planet Electronic Circular* came out,[2] only A and B were still active. Images released by the *Hubble Space Telescope* obtained on Apr 20 & 23 show multiple fragments, but the two groups corresponding to A and B are clear (Figure 7).

At the time of writing, fragment B appears reasonably stable and it will be interesting to see if it survives all the way to perihelion and beyond. It is possible to link the pre-Mar-26 astrometry of the original comet with the post-Apr-8 astrometry of fragment B. We get good residuals if we adopt a fairly significant radially outward non-gravitational parameter ($A1 = +2.31\times10^{-7} \pm 3.1\times10^{-9}$ au/d^2). This is very similar to the NGF calculated by Hui & Ye.[1]

This comet may not be the bright object that we had hoped for, but it has certainly been a fascinating object to observe and is the subject of a great demonstration of amateur observing skills.

1 Hui M.-T. & Ye Q.-Z., 'Observations of disintegrating long-period comet C/2019 Y4 (ATLAS) – a sibling of C/1844 Y1': **arxiv.org/abs/2004.10990** (2020)
2 *MPEC* 2020-H28: **bit.ly/2WLxhSP**

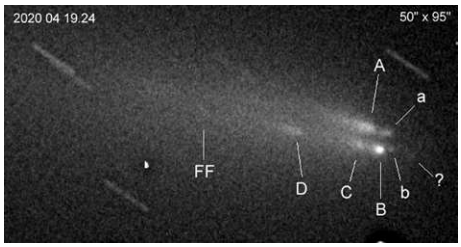

Figure 6. 2020 Apr 19.24. 2.0m *f*/10 Ritchey–Chrétien (Faulkes Telescope North, Haleakala, Hawaii); 12×20s. *Richard Miles*

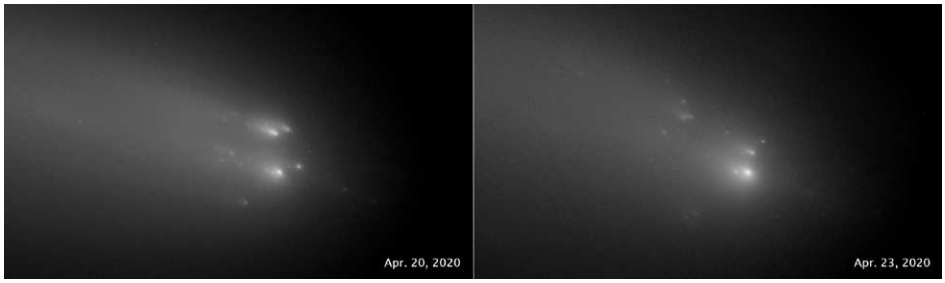

Figure 7. Images of the comet taken by the *Hubble Space Telescope* on Apr 20 & 23. On the Apr 20 image the bright SW component is B; the fainter NE component is A. By Apr 23, component A had become much less prominent. *NASA, ESA, STScI & D. Jewitt (UCLA)*