Uranus during the 2016 apparition

Kevin Bailey

A report by the Uranus Coordinator of the Saturn, Uranus & Neptune Section (Director: Mike Foulkes)

This report describes the observations of Uranus made during the 2016 apparition. Throughout this apparition, enduring atmospheric detail was observed, including distinct light zones and dark belts. A small number of spots / bright patches were observed in the North Equatorial Zone, but less frequently in other regions of the planet.

Introduction

Uranus reached opposition on 2016 Oct 15 in the constellation of Pisces, RA 1^h 23^m, Dec. +8.1°, approximately 2° NNW of the star μ (98) Psc. At opposition, its apparent magnitude was 5.7 and its apparent diameter 3.7″. Visual and digital observations were made by 22 observers between 2016 mid-July and 2017 mid-January.

Observers

The contributing observers are listed in Table 1. All observers made digital images except those marked '**V**' for visual observations only.

Historical perspective

Unlike the other major planets (with the exception of Neptune, for which a similar case can be made), Uranus has been a relatively neglected subject of popular or sustained observation by amateur and professional astronomers. In the last sixty years prior to the Uranus reports by Foulkes & Bailey (2014),[1] and Bailey (2021),[2] only two dedicated Uranus reports have been published in the *Journal*:[3,4] in 1989 and 2000 respectively, by A. J. Hollis, Director of the Asteroids & Remote Planets Section, and covering the period 1954–1997. Forty-one observers contributed observations during the 43 years covered by these reports, of which 26 were magnitude estimates made exclusively using binoculars.

Table 1. Contributing observers

Observer	*Location*	*Instrument used*	*Camera*	*Filter*
Abel P. **V**	Leicester	203mm Newt.		
Arditti D.	Edgeware, Middlesex	356mm SCT		
Bailey K. N. L. **V**	Swindon, Wiltshire	280mm SCT		
Bosman R.	Enschede, The Netherlands	356mm SCT		
Cazard J. P.	Pic du Midi, France	106cm Cass.	ZWO ASI 1290MM	685nm IR
Clitherow A.	Fife, Scotland	254mm Newt.		
Colas F.	Pic du Midi, France	106cm Cass.	ZWO ASI 1290MM	685nm IR
Delcroix M.	Pic du Midi, France	106cm Cass.	ZWO ASI 1290MM	685nm IR
Foulkes M. **V**	Henlow	280mm SCT		
Gray D. **V**	Kirk Merrington, Co. Durham	415mm DK Cass. + binoviewers		
Guidi M.	San Pietro Polesini, Italy	600mm Dob.	Unspecified	IR filter
Hillebrecht R. A.	Bad Gandersheim, Germany	356mm SCT	ZWO ASI 224MC	685nm IR
Lewis M.	St. Albans, Hertfordshire	444mm Dob.		
Maksymowicz S. **V**	Ecquevilly, France	150mm OG 200mm MC 305mm SCT		
Martinez E.	Sant Feliu de Guixols, Spain	305mm Newt.	ZWO ASI 120MC	IR/UV cut
Melillo F. J.	Holtsville, NY, USA	280mm SCT	DMK 21AU619AS	610nm IR
Milika D. & Nicholas P.	Australia	356mm SCT	ZWO ASI 290MM	685nm IR
Pellier C.	Pic du Midi, France	106cm Cass. 250mm Gregorian	ZWO ASI 1290MM ZWO ASI 224MC	685nm IR IR cut
Sussenbach J.	Houten, The Netherlands	356mm SCT	ZWO ASI 290MM ZWO ASI224MC	610nm IR 610nm IR
Walker G.	Macon, Georgia, USA	254mm OG	ZWO ASI 174MM	Astronomik Type2c
Wildgoose K.	Oswestry, Shropshire	356mm SCT	ZWO ASI 224MC	685nm IR

Abbreviations: SCT = Schmidt–Cassegrain (Telescope); Cass. = Cassegrain; DK = Dall–Kirkham; Dob. = Dobsonian; OG = object glass (refractor); MC = Maksutov–Cassegrain; Newt. = Newtonian.

Note: (i) IR (infrared) filters pass light at specific wavelengths within the non-visual red end of the electromagnetic spectrum and are used (primarily with digital 'astro' cameras) to produce long-exposure IR images: these have the potential to reveal non-visual details on a planet's surface or atmosphere. (ii) A longpass (LP) filter attenuates shorter wavelengths while passing those at its designated wavelength. (iii) RGB visual filters are used with monochrome digital cameras to produce colour images. (iv) UV (ultraviolet) and IR 'blocker' or 'Luminance' filters theoretically improve the quality of processed digital images.

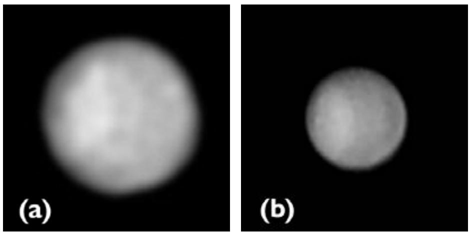


Figure 1. (a) 2016 Jul 18, 01:52 UT. CM = 257.7°. 356mm SCT, 610nm IR filter, ASI 290MM camera. *J. Sussenbach*. **(b)** 2016 Aug 15, 01:56 UT. CM = 252.8°. 600mm Dobsonian, 610nm IR filter (camera unspecified). *M. Guidi*

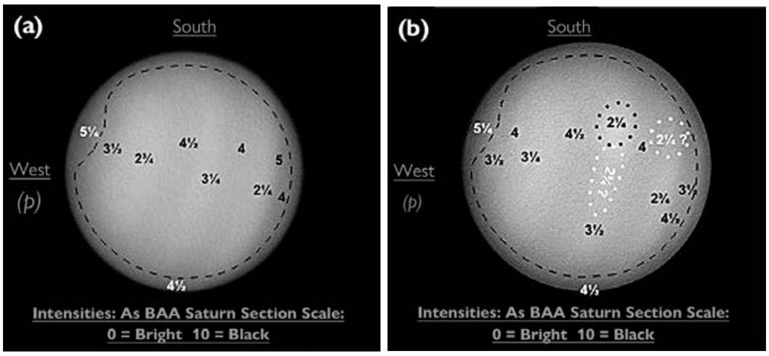


Figure 2. Drawings and intensity estimates made by D. Gray. **(a)** 2016 Aug 2, 02:30 UT. CM = 229°. **(b)** 2016 Oct 2, 23:10 UT. CM = 273°. 415mm Dall–Kirkham (×365 & ×610 with binoviewers).

Only eight observers used instruments with an aperture exceeding 200mm. It is worth noting that David Gray, one of these veteran observers, has been contributing visual observations of Uranus regularly from 1969 up to the present day, and is arguably the most experienced visual observer of the planet still active.

With the gradual supplanting of visual observations by digital imagery since the 1990s, a handful of observers have made considerable progress recording detailed images of Uranus, notable among them being John Sussenbach, who since 2006 has consistently improved the digital view of the planet. Aspiring Uranus imagers are encouraged to read the recent *Journal* paper describing his Uranus work in 2006–2016.[5]

The author has singled out Gray and Sussenbach because they admirably represent the two methods of observing – visual and digital – that are of equal value, especially when used comparatively, to enable the confirmation of elusive atmospheric detail. This report is an attempt to 'normalise' Uranus as an equal among its planetary peers, and encourage amateur observers to make it the subject of regular observing and reporting.

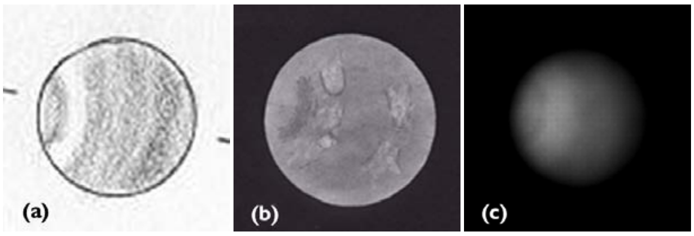


Figure 3. (a) 2016 Oct 2, 21:30 UT. CM = 238°. 305mm SCT. *S. Maksymowicz*. **(b)** 2016 Oct 26, 20:05 UT. CM = 356.3°. 280mm SCT. *K. Bailey*. **(c)** 2016 Nov 26, 11:41 UT. CM = 236.2°. 356mm SCT, 685nm IR filter, ASI 290MM camera. *Milika & Nicholas*

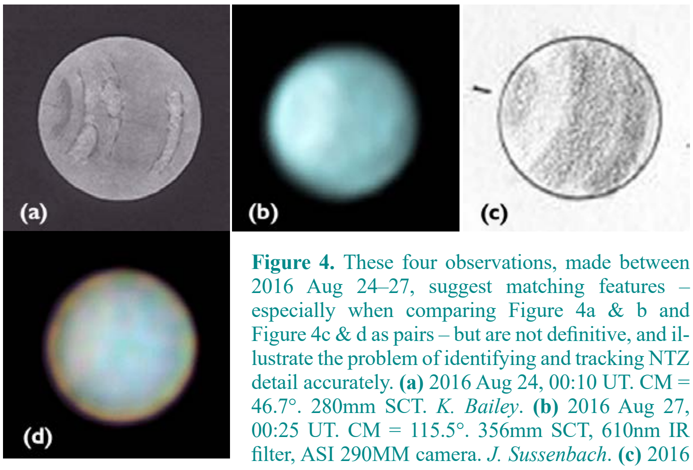


Figure 4. These four observations, made between 2016 Aug 24–27, suggest matching features – especially when comparing Figure 4a & b and Figure 4c & d as pairs – but are not definitive, and illustrate the problem of identifying and tracking NTZ detail accurately. **(a)** 2016 Aug 24, 00:10 UT. CM = 46.7°. 280mm SCT. *K. Bailey*. **(b)** 2016 Aug 27, 00:25 UT. CM = 115.5°. 356mm SCT, 610nm IR filter, ASI 290MM camera. *J. Sussenbach*. **(c)** 2016 Aug 27, 22:45 UT. CM = 221°. 200mm Mak–Cass. *S. Maksymowicz*. **(d)** 2016 Aug 25, 03:36 UT. CM = 259.8°. 305mm Newtonian, IR/UV cut filter, ASI 120MC camera. *E. Martinez*

Observing methods: visual & digital

Professional studies present a model of the Uranian troposphere with a definite vertical structure in which methane condenses as it rises – first into clouds, then into more reflective methane ice.[6] Within the scope of amateur observation, it would be logical to assume that visual observers are seeing the bright methane clouds high in the Uranian troposphere (brighter still, these clouds condensing into more reflective methane ice) – whereas digital observations, using near-IR filters, are probing deeper into the troposphere and identifying the more dense cloud features (and some condensation haze). With this in mind, where possible, this report has matched visual and IR observations in an attempt to present a more dynamic three- rather than two-dimensional picture of the troposphere of Uranus.

For the sake of uniformity, the drawings and images are presented 'south up' (as is the current BAA convention), with the north pole aligned to the left – unless otherwise indicated. In the future it may be necessary for regular Uranus

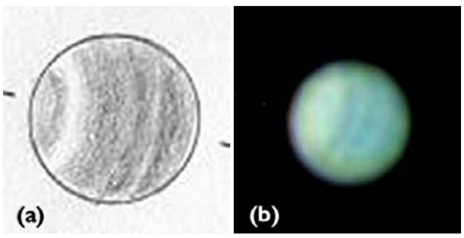


Figure 5. (a) 2016 Sep 21, 21:55 UT. CM = 136°. 305mm SCT. *S. Maksymowicz*. **(b)** 2016 Dec 15, 18:55 UT. CM = 188.2°. 356mm SCT, 610nm IR filter, ASI 290MM plus ASI 224MC cameras. *J. Sussenbach*

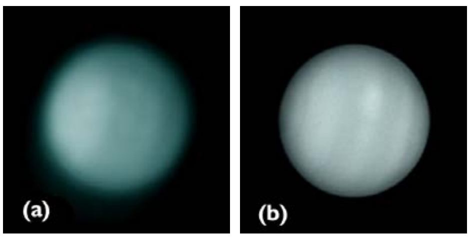
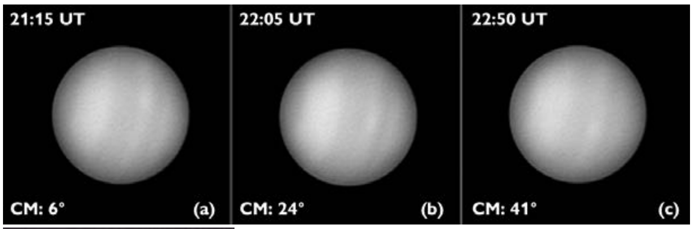


Figure 6. (a) 2016 Oct 2, 22:36 UT. CM = 261.2°. 356mm SCT, 685nm IR filter, ASI 224MC camera. *K. Wildgoose*. **(b)** 2016 Oct 2, 23:10 UT. CM = 273°. 415mm Dall–Kirkham (×365 & ×610 with binoviewers). *D. Gray*



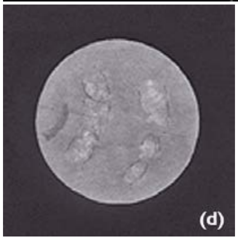


Figure 7. (a–c) Three sequential drawings by *D. Gray*, 2016 Oct 31, 21:15–22:50 UT. CM = 6–41°. 415mm Dall–Kirkham (×365 & ×610 with binoviewers). **(d)** One drawing by *K. Bailey*, 2016 Oct 31, 21:50 UT, CM = 18.6°. 280mm SCT.

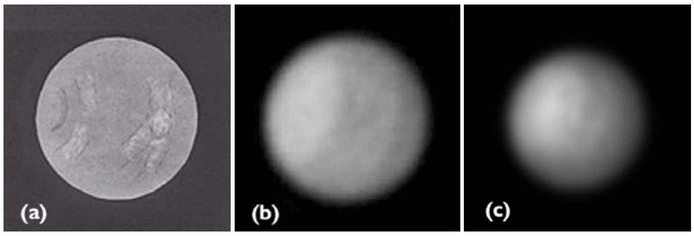


Figure 8. Possible 'fork' in the NEZ. **(a)** 2016 Oct 5, 21:30 UT. CM = 301°. 280mm SCT. *K. Bailey*. **(b)** 2016 Nov 2, 22:15 UT. CM = 309.5°. 356mm SCT, 610nm IR filter, ASI 290MM camera. *J. Sussenbach*. **(c)** 2016 Nov 18, 01:14 UT, CM = 329°. 254mm OG, Astronomik Red Type 2C filter, ASI 174MM camera. *G. Walker*

observers to discuss and agree a standard method of reporting regarding the orientation of the planet.

The observations

Significant advances were made with regard to amateur observation of Uranus during the 2016 apparition. These are primarily the confirmation of distinct and enduring atmospheric belts and zones by multiple observers. Latitude measurements were made as precisely as possible using the software *WinJUPOS*, but due to the small size of digital images – and difficulty in making precise visual drawings of such a small disc – a possible error factor of 5–10° has to be taken into account. Regions on the planet's disc are defined using the terminology established in the 2015 Uranus report:[2] i.e., NPR – North Polar Region, NPB – North Polar Belt, NTZ – North Temperate Zone, etc.

The North Polar Region & North Polar Belt

The existence of a distinct NPR was recorded throughout the apparition by both visual and digital observers, extending from the north pole to approximately lat. 75°N. Digital images by J. Sussenbach on 2016 Jul 18 (Figure 1a) and M. Guidi on 2016 Aug 15 (Figure 1b) show the NPR, and are complementary to detailed drawings (with intensity estimates shown) made by D. Gray (Figure 2a & b) on 2016 Aug 2 and 2016 Oct 2. His intensity estimates for this feature over seven observations (2016 August–November) average 4.7 on the Saturn Scale – a relatively dark feature less often recorded digitally than visually, and at present we can only speculate that this may be due to filter wavelength or processing factors.

The NPB was also recorded regularly throughout the apparition, both visually and digitally (Figure 3) – an interesting feature, often seen more clearly when the NPR was lighter. It is circumpolar and appears as a dark narrow band situated between lat. 75–65°N, with a well-defined border at 75°N separating it from the NPR. This can be seen clearly in an image taken by Milika & Nicholas on 2016 Nov 26 (Figure 3c). Maksymowicz (Figure 3a) and Bailey (Figure 3b) recorded the dark band visually.

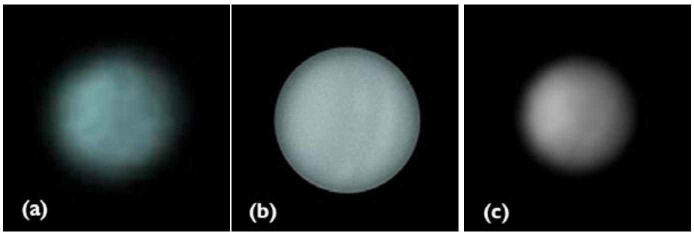


Figure 9. (a) 2017 Jan 1, 23:37 UT. CM = 165°. 280mm SCT, 610nm IR filter, DMK 21AU619.AS camera. *F. J. Melillo*. **(b)** 2017 Jan 2, 18:05 UT. CM = 191°. 415mm Dall–Kirkham, ×490 & ×610 binoviewers. *D. Gray*. **(c)** 2017 Jan 15, 11:47 UT. CM = 94°. 356mm SCT, 685nm IR filter, ASI 290MM camera. *Milika & Nicholas*

Figure 10. 2016 Nov 7, 22:57 UT. CM = 309°. 203mm Newtonian. *P. Abel*

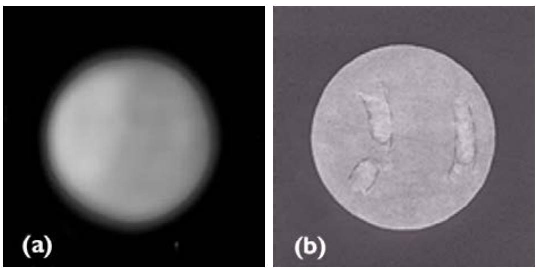


Figure 11. (a) 2016 Sept 8, 23:24 UT. CM = 129.7°. 356mm SCT, 610nm IR filter, ASI 290MM camera. *J. Sussenbach*. **(b)** 2016 Sep 8, 22:45 UT. CM = 116.2°. 280mm SCT. *K. Bailey*

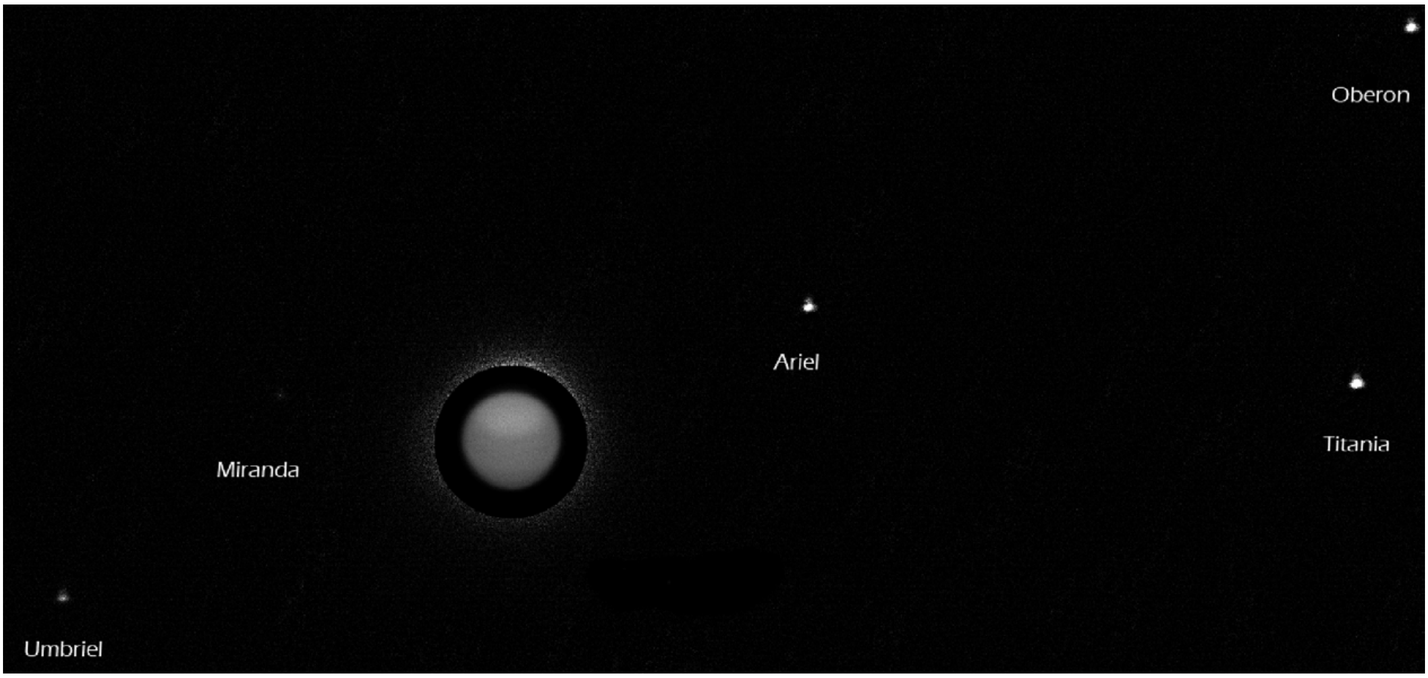


Figure 12. Still image taken from an animation of the major moons on 2016 Aug 8, 02:38–03:25 UT. CM = 359–15°. Pic du Midi 106cm Cassegrain, 685nm IR filter, ASI 290MM camera. *M. Delcroix, C. Pellier, J. P. Cazard, F. Colas*

Though elusive and variable, the NPB was an enduring feature throughout the apparition – Maksymowicz recorded it in 19 of his 43 observations, and Bailey in 18 out of 26.

The North Temperate Zone & North Temperate Belt

The bright North Temperate Zone (NTZ), at approx. lat. 65–45°N, showed a great variability of texture – sometimes patchy, and at other times smooth and well defined – regardless of whether the observation was made visually, or digitally. The observations shown in Figure 4 demonstrate this and highlight the difficulty of identifying distinct features in the NTZ, for although they undoubtedly exist at times (as evidenced by the NTZ bright spot of 2014), matching two or more observations to confirm their existence and movement remains rare, due to the infrequency and small number of observations to compare – despite the NTZ being the most frequently recorded feature on the planet.

The North Temperate Belt (NTB), at lat. 45–20°N, remained dark and unremarkable during this apparition, mottled occasionally with indistinct light markings that appear almost exclusively in digital IR images, and therefore *may* be processing artefacts.

The North Equatorial Zone & Equatorial Belt

A comprehensive visual observation by Maksymowicz (Figure 5a) and image by Sussenbach (Figure 5b) show all the major belts and zones so far identified by amateurs, including the bright North Equatorial Zone (NEZ) at approx. lat. 20–0°N, and dark Equatorial Belt (EB) at approx. lat. 0–10°S.

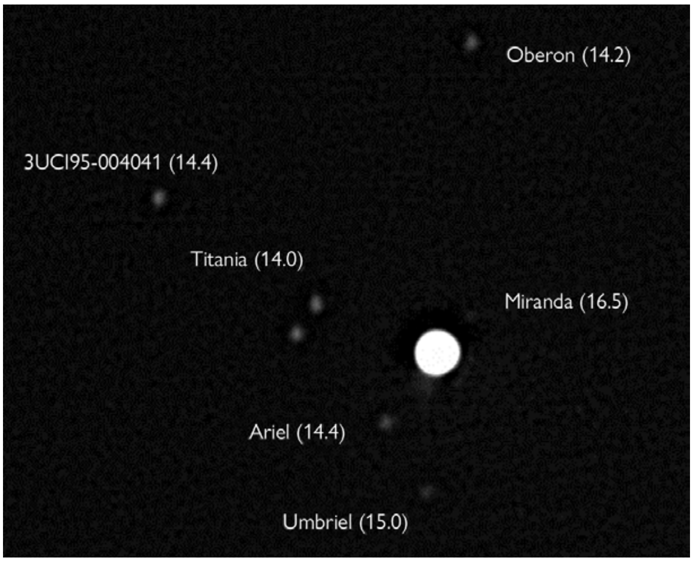


Figure 13. The major moons imaged by *R. A. Hillbrecht*, 2016 Dec 5, 19:59 UT. 356mm SCT, 685nm IR filter, ASI 224MC camera.

One of the significant aspects of the 2016 apparition was the durability and frequency of markings being observed, or suspected, in the NEZ. A matching pair of IR/visual observations by Wildgoose (Figure 6a) and Gray (Figure 6b) demonstrate how both observing methods record similar markings within the NEZ.

Figure 7 shows light markings at circa long. 30°, lat. 15°N in the NEZ on 2016 Oct 31, recorded visually by Gray and confirmed by Bailey.

During 2016 November, Maksymowicz, Bailey, and Walker noted a brightening of the NEZ. On 2016 Oct 5, Bailey observed what *appeared* to be a 'fork' in the NEZ at central meridian longitude (CM) = 301° (Figure 8a). The existence of this feature was confirmed by an image taken by Sussenbach on 2016 Nov 2

(Figure 8b), which located it at the same latitude and CM = 309.5° These complementary observations suggest that the feature remained at approximately the same position for a month – but may have been fading, as only the most generous interpretation of Walker's image of 2016 Nov 18 (Figure 8c), CM = 329°, would suggest it had endured.

A limb-brightening event in the NEZ imaged by Sussenbach on 2016 Dec 5, 19:20 UT, was confirmed visually by Maksymowicz on 2016 Dec 5, 21:20 UT, and described by him as 'stunning'. Other markings were identified and recorded in the NEZ during the latter part of the apparition by Melillo (Figure 9a), Gray (Figure 9b), Milika & Nicholas (Figure 9c), and others. Due to the limited number of observations during this period, the movement of specific markings in the NEZ could not be measured with any degree of certainty – despite their obvious frequency.

The dark EB was not as distinct during this apparition compared with its appearance in 2015, but S. Maksymowicz's drawing (Figure 5a), D. Gray's drawings (Figure 7), J. Sussenbach's image (Figure 8b) and a detailed drawing by P. Abel (Figure 10), do show this dusky belt.

The South Equatorial Zone

The South Equatorial Zone (SEZ) at approx. lat. 10–30°S can be an elusive feature in digital images but is frequently recorded by visual observers. A pair of complementary observations confirming a bright marking in the SEZ on 2016 Sep 8, by Sussenbach and Bailey (Figure 11a & b), emphasise the necessity of making regular observations throughout an apparition. It is stating the obvious to point out that the larger the number of observations made, the greater the chance of matching them to confirm atmospheric detail and variations.

The satellites & rings

The five brightest moons of Uranus were recorded by several observers throughout the apparition, notably by the team at the Pic du Midi, who on 2016 Aug 8 (Figure 12) animated a detailed movement of the five brightest moons over a 40-minute period.

The capture of the major moons by observers using digital cameras and relatively modest instruments (Figures 13–16) opens up the possibility of making regular photometric / visual intensity estimates of the moons.

The amateur detection of Uranus' rings has already been discussed and illustrated by David Arditti,[7] and there is strong evidence that experienced imagers using instruments in the circa 36cm-aperture range have seen the rings – or rather, the unresolved light of the epsilon ring. But, as Arditti cautions, 'It is clear that excellent seeing and good low-scatter optics are essential in detecting the rings'.

It is probable that for the foreseeable future, imaging the rings will remain the province of very experienced imagers using finely tuned telescopes, but should a serendipitous occultation by a bright star occur, it may be possible for the ring system to be measured indirectly using long-established visual methods. It would be very challenging work but given the progress amateur observers have made in relation to the study of Uranus over the last decade, it is entirely possible that experienced imagers (or visual observers possessing large-aperture instruments) could track an occultation.

Figure 14. Uranus and moons imaged by *M. Lewis*, 2016 Dec 29, 19:07 UT (moons), 19:41 (planet). CM = 20°. 444mm Dobsonian, 610nm IR filter, ASI 224MC camera.

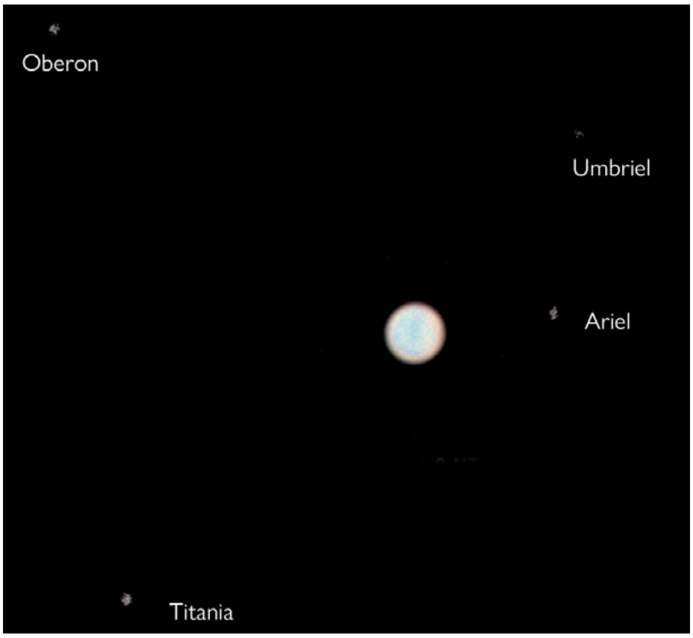


Figure 15. Uranus and moons imaged by *C. Pellier*, 2016 Aug 31, 02:30 UT. CM = 4°. 250mm Gregorian, IR cut filter, ASI 224MC camera.

Conclusion & discussion

In the last decade, there has been a slow and incremental growth in the number of amateurs making observations of Uranus, and these observers have adapted quickly to the difficulties inherent with regard to such a challenging subject. Their work has shown that Uranus is a dynamic planet and that the monitoring of its atmosphere, moons – and perhaps even its rings – is possible using ‘modest’ amateur instrumentation: the proof is the work done by amateur observers during the 2016 apparition.

We now have general confirmation of the following disc features (as first provisionally outlined in Figure 11 of the 2015 Uranus apparition report.[2] (i) A dark polar region (NPR) extending from approx. lat. 90–75°N. (ii) A dark belt/collar (NPB) encircling the NPR at approx. lat. 75–65°N. (iii) A bright North Temperate Zone (NTZ), brighter in IR than visible light, showing a patchwork of clouds and brighter ‘spots’, at approx. lat. 65–45°N (the distinct bright spot of 2014 was located in the NTZ). (iv) A dark North Temperate Belt (NTB) at approx. lat. 45–20°N, bound by (v) a bright, but relatively narrow, North Equatorial Zone (NEZ) at approx. lat. 20–0°N that has been shown to contain trackable bright patches/‘spots’, and a bright fork extending into the dark NTB. (vi) A dark Equatorial Belt (EB) at approx. lat. 0–10°S, bound by (vii) a bright but relatively narrow South Equatorial Zone (SEZ) at approx. lat. 10–30°S. As stated, these belt and zone latitudes are approximations, based on *WinJUPOS* measurements of the 2015 and 2016 observations. It is worth noting that the size and nature of the belts can vary depending upon the recording wavelength being used by the observer.

The observed colour of Uranus also appears to depend on variables that include the wavelength sensitivity of the observer’s eye, the instrument being used, and the seeing conditions. Therefore, visual colour descriptions range from a light blue, through turquoise, to light green. The famous planetary observer E. M. Antoniadi, using the 83.8cm (33-inch) Meudon refractor in 1924, described the planet as having a yellow greenish blue colour – a description that rather supports the caveats regarding colour mentioned above.[8]

The aspect of Uranus moves towards a northern ‘pole-on’ presentation during the late 2020s and early 2030s, consequently diminishing opportunities to measure and record the northern hemisphere’s belts and zones. It would, therefore, be useful to maximize the number of observations of these features during the next four or five apparitions. The pole-on presentation will of course allow the study of an area of the planet not fully seen since 1946, and – possibly – the full rotation of features in the higher latitudes of the northern hemisphere.

This report is evidence that real progress is being made by amateur observers prepared to devote time and effort to the difficult task of observing Uranus. Further progress will depend on a larger group of *regular* observers collaborating and pooling their observations. As A. J. Hollis said 25 years ago, it is essential that; ‘observations are reported so that they may be included in the database and used in the analysis of the planet’.[4] The benefit of sending observations to the Section Director or Uranus Coordinator is that they can cross-reference the data, match observations, and confirm the discovery of new features seen by any individual observer. This collaborative approach, so successfully applied to other planetary subjects, seems the best way to refine and develop our understanding of Uranus.

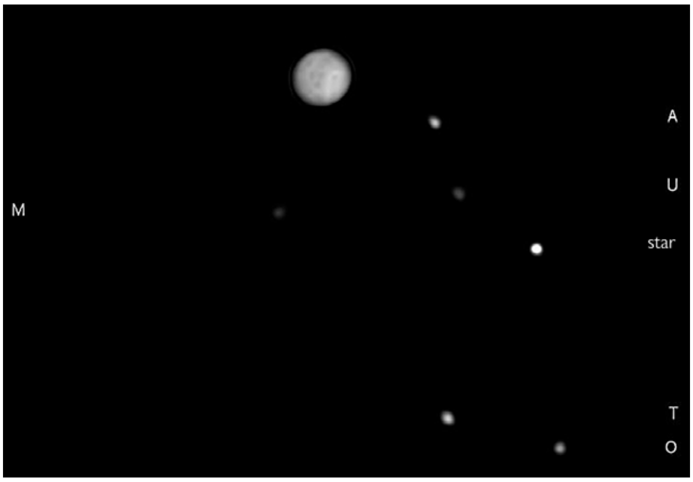


Figure 16. Uranus and moons imaged by *J. Sussenbach*, 2016 Aug 11, 00:15 UT. CM = 12.9°. 356mm SCT, IR filter, ASI 290MM camera.

Address: 4 Ellingdon Road, Wroughton, Wilts. SN4 9HY *[hqbailey@googlemail.com]*

References

1 Bailey K. & Foulkes M., ‘Observations of Uranus in 2014’, *J. Br. Astron. Assoc.*, **125**(2), pp 68–70 (2015)
2 Bailey K., ‘Uranus during the 2015 Apparition’, *ibid.*, **131**(5), pp 283–286 (2021)
3 Hollis A. J., ‘Uranus 1954 to 1986’, *ibid.*, **99**(2), pp 59–62 (1989)
4 Hollis A. J., ‘Uranus 1987–1997’, *ibid.*, **110**(3), pp 124–126 (2000)
5 Sussenbach J., ‘Observing Uranus and its satellites’, 2006–2016, *ibid.*, 2017, **127**(4), pp 203–206
6 Irwin P. G. J. *et al.*, ‘Uranus’ cloud structure and seasonal variability from Gemini-North and UKIRT observations’, *Icarus*, **212**, pp 339–350 (2011)
7 Arditti D., ‘Amateur detection of Uranus’ rings’, *J. Br. Astron. Assoc.*, **127**(1), p.50 (2017)
8 Alexander A. F. O’D., *The Planet Uranus*, Faber & Faber, 1965, p.235

Reading

Schmude Jr., R.; Uranus, Neptune, and Pluto – and how to observe them, Springer, 2008

Received 2022 March 30; accepted 2022 May 25