Journal for
Occultation Astronomy

International Occultation Timing Association

Volume 8 · No.4 2018-04

Beyond Jupiter: Makemake

Dear reader,

On August 15th, Pluto occulted a 12.9 mag. star across the USA, the brightest occultation by Pluto since the New Horizons flyby in 2015. It was a good opportunity to study the evolution of Pluto's atmosphere. In a great collaboration between the Southwest Research Institute, the Lucky Star Project, the Univ. of Virginia, and IOTA, the occultation was very well-observed. Incredibly, the Lucky Star prediction for the central line, around which several central flash recordings were made, was accurate to within 20 km. This shows the power of the Gaia DR2 stellar data, which Lucky Star used to re-analyze all of the past observed Pluto occultations, to improve the ephemeris. It's time for IOTA to apply similar methods, to improve the predictions for occultations by the closer asteroids. Some first attempts are described on pages 6 to 10. The Main Belt asteroids move faster than the TNO's, so a simple correction to the ephemeris works for only one apparition. We are starting to implement a system to keep track of observed path shifts, as noted in the conclusions on p. 10, but we need your help. Please report your observations promptly, especially if a significant shift is obvious. More will appear soon on the email lists. The upcoming occultations by the "dogbone" asteroid Kleopatra might be an important first test. Also below are articles about observations of this year's brightest asteroidal occultation, a rare opportunity with the large asteroid (164) Eva, minutes of the 2018 IOTA meeting, and Oliver Klös's project for preserving Occultation Newsletter, the predecessor to JOA. Finally, Paul Maley, with help from local observers, recorded the Sept. 16th Sappho occultation from 6 stations in California, while Joan and I observed the last Aldebaran graze of the current series in July, both events noted on p. 23 of the previous issue.

Clear skies

David W. Dunham

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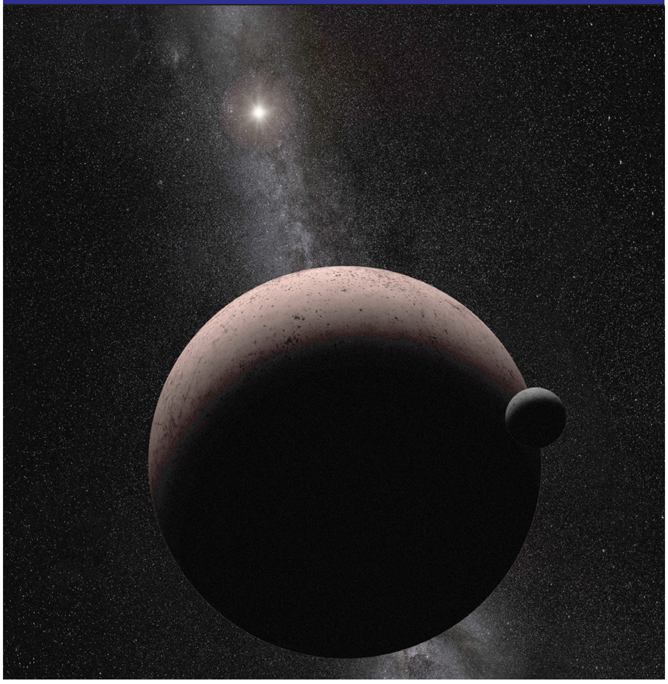
In this Issue:

COVER



The distant dwarf planet

Makemake

This artist's concept shows the distant dwarf planet Makemake and its newly discovered moon, nicknamed MK
Credits: NASA, ESA, and A. Parker (Southwest Research Institute)

Rules for Authors

In order to optimize the publishing process, certain rules for authors have been set up how to write an article for JOA. They can be found in "How to Write an Article for JOA" published in this JOA issue (2018-3) on page 13. They also can be found on our webpage at http://www.iota-es.de/howtowrite.html .

Journal for
Occultation Astronomy

Occultation of Sabik (η Ophiuchi A) by (369) Aeria, 2018 February 18

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ABSTRACT: On February 18 UT (19th local date), the brightest star occulted by a sizeable asteroid during 2018 occurred in eastern Australia. The star was η Ophiuchi = Sabik = HIP 84012 = WDS 17104-1544 = BU 1118AB, a nearly equal binary. This article describes the special efforts needed to predict the path of the occultation by the primary star, the effort to observe the event from multiple remote stations, and the successful observations, with a good elliptical fit to the three positive chords.

Prediction

The goal was to observe the occultation by the 3.0-magnitude primary (A) component. The path for the 3.5-mag. B component was about 600 km farther north and not observed; it was probably too cloudy in that area, near Townsville, Queensland (Qld). The star was too bright for Gaia Data Release 1, so the best data for it are from the HIPARCOS 2 (HIP2) catalog. Those data, only for the A component and with a 1991 epoch [1], did not take into account the orbital motion. With periastron expected in 2025, with an 85yr period and high eccentricity, and current separation of 0.5″ (the angular diameter of Aeria was expected to be only 0.034″) the effects of neglecting the orbit are significant; see the orbit in Fig. 1.

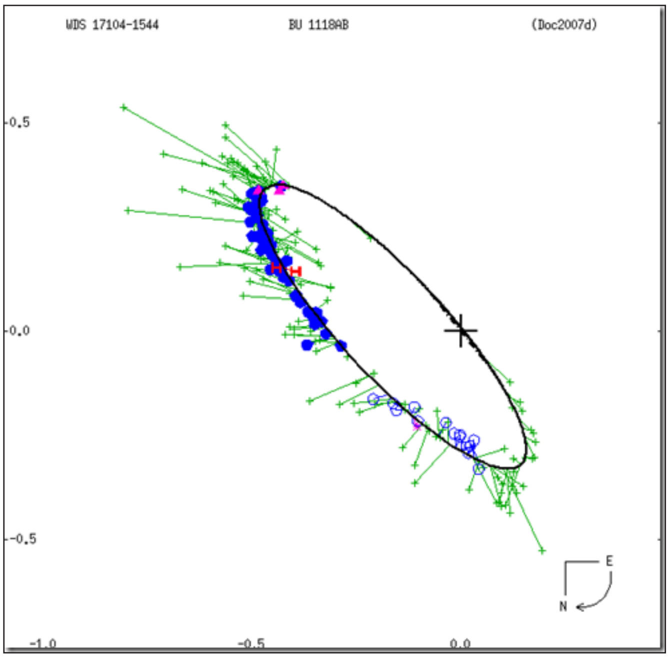

Fig. 1. Orbit of η Ophiuchi, from [2]. The horizontal and vertical axes are in arc seconds, in right ascention and declination, respectively.

The first prediction for the occultation used the HIP2 data as they were. In order to take into account the orbital motion, it was necessary to shift the HIP2 position from the A-component position given by HIP2 at the 1991 HIP2 epoch, to the barycenter of the binary system, then subtract the components of the proper motion due to the orbital motion, apply this corrected proper motion to the occultation epoch, and then shift the position back to the A-component at the occultation epoch. Brian Mason at the U. S. Naval Observatory kindly provided the delta-RA, delta-Dec values of the B component from the A component that he computed from [2], to more precision than can be calculated with a Web-based tool [3] that at least successfully double-checked Mason's numbers. But to do this, the masses of the components are needed, to shift to and from the barycenter. Although these should be readily found from the ratio of the amplitudes of the variation of the lines in the spectra, David Dunham was not able to find information about those amplitudes in the literature. The values Dunham used for the masses, A = 2.3 $M_\odot$ and B = 2.0 $M_\odot$, were calculated from the stars' luminosities, temperatures, and stellar evolution theory [4]. Dunham then performed the calculations with an Excel spread sheet. He wasn't 100% confident in these calculations, or that the errors of the binary orbital elements were realistic, and the errors of the component masses were unknown. A successful test calculation was made for the occultation of the same star by the asteroid (278) Nephthys that was observed from Pic du Midi Observatory in France by J. Lecacheux and F. Colas on 2004 September 6; that remains the only occultation of a star by an asteroid observed in daylight. But the test was not a good one, as the correction for the orbital motion in 2004 was insignificant, only a 7th of what it would be in 2018, due to the closeness of the latter to the periastron epoch. The prediction at IOTA's main prediction Web site at http://www.asteroidoccultation.com was updated by Steve Preston using Dunham's corrections for the A component on 2018 February 2. A separate prediction for the B component was added eight days later.

Observations

Four days before the occultation, the Dunhams travelled to southeastern Queensland, where they were kindly hosted by John Broughton, at Reedy Creek in the Gold Coast area. John planned to deploy up to 9 stations across the path and the northern uncertainty zone, while Joan and David decided to go inland about 500 km, to use St. George, Qld. as a base to also deploy across the path, but concentrating on it and the southern uncertainty zone; the weather was expected to be better there. The Dunhams hoped to deploy as many as 11 mighty mini [5] stations, but the evening before the night of the event, David came down with a severe 24h flu. By the next afternoon, he recovered, but very weakened, he decided to regain some strength by sleeping a few hours in the early pm, leaving the motel at 10pm for the 3am event, hoping to deploy 6 stations rather than 11. Both efforts ran out of time; John had clouds at one station and deployed 7 stations, while the Dunhams managed 5; avoiding kangaroos made night driving slow. After pre-pointing, all of the mighty mini's and other optics used were defocused to prevent saturation of the bright star's images in the videos. The Dunhams recorded the occultation from their 3 middle stations, with a miss (no event) at their northernmost Station 1 and southernmost Station 5. Although the seeing was poor, with large scintillation variations, the occultation events were clear; the magnitude drop was 0.86 since the B component remained unocculted. The event timings were determined from the Limovie-produced light curves using PYOTE. We thank Tony George for help with the analysis of the video recordings. John had misses at all his stations, with his southernmost Station 7 being closest to our positive Station 2 relative to the path; see Fig. 2. The green line shows the nominal prediction, including Dunham's correction for the binary orbital motion, while the yellow line is the Hipparcos 2 prediction, without any correction for the binary orbit. The blue lines are the predicted northern and southern limits, while the red lines are the limits in case of a 1-sigma shift of the path to the north or south. The observations showed a 25 km (about 0.3 path-widths, 0.010", or 0.3 sigma) south shift of the path from the nominal. But the event occurred 6s early, a 162-km shift along the path, which is 0.071", 7 times the cross-track error.

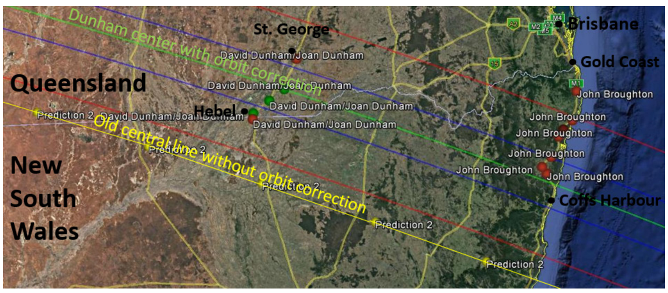

Fig. 2. Google map of the predicted path. The green dots mark stations that recorded the occultation while red dots mark those that had a miss; by Brad Timerson.

Dunham Station 5

After the Dunhams had set up Station 4, they were running short of time, so they drove only about halfway from Station 4 to their intended Station 5. Thus, their actual Station 5 location, just 4 km south of the Queensland-N.S.W. border, was farther north than desired, only about 7 km south of Station 4 in the sky plane at Aeria. The first review of the Station 5 recording showed a miss, but a more careful review showed a small dimming at the right time, but not with a depth as large as that expected from a real occultation, at "A" in the Fig. 3 light curve. But the seeing was terrible and there were many other dimmings, including a stronger one at B, 17s after the closest approach time at A, that must have been atmospheric as it was more than 100 km from Aeria on the sky plane.

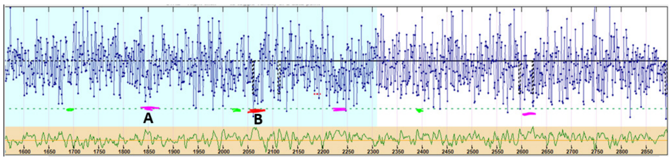

Fig. 3. Light curve of Sabik at Dunham Station 5 near Angledool, New South Wales, generated from the video recording by Dave Herald.

Analysis and Results

Fig. 4 shows the best-fit ellipse, with dimensions of 64 by 54 km. Although the evidence for a real event at Dunham Station 5 (line 13 in Fig. 4) from the light curve is weak, the best-fit ellipse from the clear occultations at Stations 2-4 (lines 9, 11, & 12) shows a graze at Station 5. Although this is evidence that dip "A" is a true graze, the actual shape of Aeria is irregular, so we can't know for sure; officially, it will be called a miss (likely atmospheric).

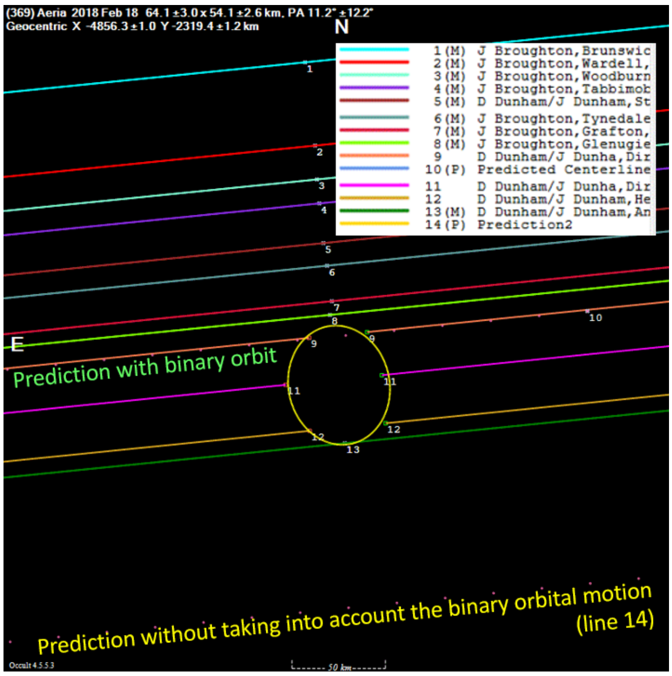

Fig. 4. Occult 4 Sky Plane Plot, 2018 Feb. 18 occultation of η Ophiuchi A by (369) Aeria, by Brad Timerson.

Sabik is not in either Gaia DR1 or DR2. But most stars have accurate positional data from Gaia DR2, so observations of future occultations by Aeria can be used to improve the orbit of Aeria, to then improve the position of Sabik A on 2018 February 18. Before this occultation, there were only two observed occultations by Aeria: on 1989 Nov. 21 by Jim Blanksby in Melbourne, Vic., AU and on 2015 Dec. 11 by Roger Venable in Florida (positive from two stations and misses from two more stations). Re-analysis of these with Gaia DR2 data might also help.

References

[1] F. van Leeuwen, Validation of the new Hipparcos reduction, Astronomy & Astrophysics, 474: 653-664 (2007).

[2] J. A. Docobo and J. F. Ling, Orbits and System Masses of 14 Visual Double Stars with Early-Type Components, Astronomical Journal, 133: 1209-1216 (2007).

[3] R. Wessen, Binary star position angle and separation calculator, https://www.nebulousresearch.org/codes/binaries/, accessed 2018 February.

[4] J. Kaler, Sabik, http://stars.astro.illinois.edu/sow/sabik.html, accessed 2018 May.

[5] S. Degenhardt, Multi-Station Occultation Observing with Galileo Sized Optical Systems, a chapter in Small Telescope and Astronomical Research, Collins Foundation Press, Kimball, Michigan (2009).

CALL FOR OBSERVATION:

Three Occultations by (164) Eva in Four Days

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ABSTRACT: Observers in Europe have the chance to measure two different profiles of (164) Eva during occultations on 2018 Oct 31 and Nov 4. Observers in the Northeast of U.S.A. and Canada can observe another profile on 2018 Nov 03.

The Events

(164) Eva occults a 9.4 mag star in constellation Gemini around 04:33 U.T. on 2018 Oct 31. The expected maximum duration is expected to be 9.3 sec. The predicted path will cross the East of Ireland and Northern Ireland, and Northern U.K.[1]. Three days later, observers in eastern Canada have the opportunity to observe an occultation by (164) Eva of a 12.5 mag star with a duration of 9.7 sec at 06:20 U.T. on Nov 03 [2]. Less than 24 hours later, the minor planet will occult a 12.2 mag star around 01:10 U.T. on Nov 04. The predicted path crosses West and North Africa, France, Belgium and the Netherlands [3] (Fig. 1).

Figure 1 - The predicted paths for Oct 31 (red dashed lines) and Nov 04. Predictions by S. Preston, IOTA. (Map: O. Klös)

Three Different Profiles

(164) Eva rotates around its axis in 13.66 h [4]. Therefore the three upcoming occultations are well spaced in time to give three different profiles of the asteroid. If the time of the first occultation is set as a starting point, the shift of the profile between the occultations proceeds as follows:

Event	Time (U.T.)	Rotation	
		periods	deg
Oct 31	04:33	0	0
Nov 03	06:12	5.4	144
Nov 04	01:10	6.8	288

(164) Eva has a mean diameter of 100 km and a slightly angular shaped profile. Several positive chords measured during the upcoming occultations could provide high-precision astrometry of the minor planet and new insights about its shape.

References:

[1] Preston, S. Prediction of Occultation by (164) Eva, 2018 Oct 31 http://www.asteroidoccultation.com/2018_10/1031_164_57014.htm

[2] Preston, S. Prediction of Occultation by (164) Eva, 2018 Nov 03 http://www.asteroidoccultation.com/2018_11/1103_164_57036.htm

[3] Preston, S. Prediction of Occultation by (164) Eva, 2018 Nov 04 http://www.asteroidoccultation.com/2018_11/1104_164_57046.htm

[4] Frieger, G. 3D Asteroid Catalogue, Profile of (164) Eva, 2016 https://space.frieger.com/asteroids/asteroids/164-Eva#

Improving Asteroidal Occultation Predictions using Recent Past Occultations by the Same Object

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Paul D. Maley – IOTA - pdmaley@yahoo.com • Michael Skrutskie - Univ. of Virginia – mfs4n@virginia.edu

ABSTRACT: For almost two years now, we have had very accurate data for most stars from the two Gaia data releases (DRs). No asteroidal data were included in DR1, and only positions, accurate in only one direction, were given for them in the more recent DR2. So far, nobody has figured out how to use the Gaia asteroidal data to improve orbital elements. Consequently, the errors in the asteroid ephemerides, based on ground-based observations, are now more than 10 times larger than the stellar errors. We show that predictions of upcoming occultations can be substantially improved by applying corrections to the asteroid ephemeris calculated from recently-observed occultations by the same asteroid. At least, until Gaia observations of asteroids can be used to improve the orbital elements and ephemerides of those objects, IOTA can better reap the benefits of Gaia by setting up a mechanism to rapidly notify all when large shifts from the prediction are observed and documented.

2016 September 14, Occultation by (372) Palma

This occultation visible across the northern USA promised to be well-observed, with a large asteroid (over 200 km) and a relatively bright (mag. 10.3) star. Eleven observers were spread well across the predicted path, and over the two-sigma limits, yet all of them had no occultation. In the past, we would dismiss these large shifts as due to some combination of stellar or ephemeris error. This event occurred the day of Gaia DR1 release, so soon after the event, we had a very accurate position of the star; it didn't change the prediction. And Palma is a well-observed asteroid, with ephemeris errors considerably smaller than its diameter. Tony George made an independent prediction for the event, showing that the path was about 1.5 path-widths south of the IOTA predicted path, a shift of over 3 sigma. Steve Preston and Dave Herald double-checked their calculations and found an error in the reading of the asteroid ephemeris. This was quickly corrected, and within a day, the predictions for all events during the next few weeks were updated. Thus, Gaia DR1 had already paid off, to uncover and allow correction of an error that would improve all future predictions.

2016 October 13, Occultation of Regulus by (268) Adorea

Just under a month after Gaia DR1, the brightest star occulted by a sizeable asteroid in 2016 occurred in Papua New Guinea (PNG); see Fig. 1. Joan and David decided to try to observe this rare event. There are daily flights to Kavieng, a city of 17,000 at the northern end of the long New Ireland island, not far from the predicted central line; see Fig. 2. A paved road along the eastern shore of the island gave access to many possible observing sites, having a good view of Regulus rising in the east over the ocean, across the southern half of the path.

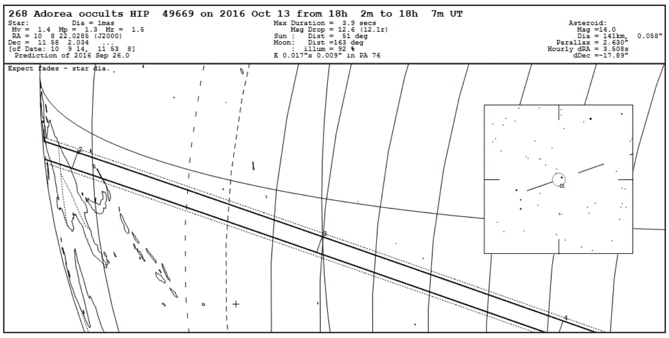

Fig. 1. Occult path map of the 2016 occultation of Regulus by Adorea.

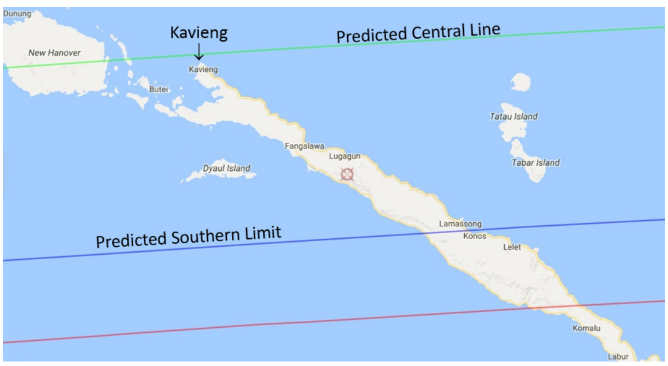

Fig. 2. Google Map path map of the 2016 occultation of Regulus by Adorea. The red line is the southern limit in case of a 1-sigma south shift.

We were concerned about the accuracy of the prediction since Adorea was just coming into visibility low at dawn, so it had been several months since the last astrometric observations of the asteroid. Fortunately, Adorea occulted a 12th-mag. star four nights before, and the event was timed by three observers in the United Kingdom. The sky plane plot of their observations is shown in Fig. 3, showing that the prediction, and therefore the Adorea ephemeris, was good, since the star was in the Gaia14 catalog produced by Dave Herald using Gaia DR1 positions and UCAC4 proper motions. Although Regulus is too bright to be in Gaia, it has been very well-observed for the FK6 catalog, using also Hipparcos data, so we were confident in the October 13th occultation prediction. We thank the U.K. observers for quickly providing us with their observations.

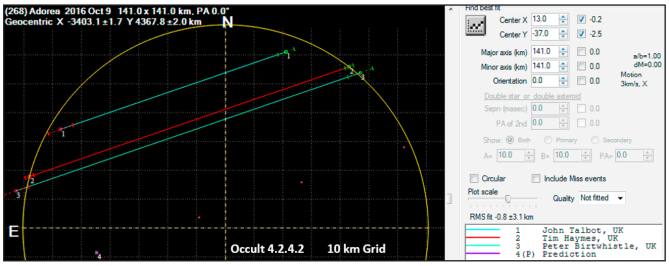

Fig. 3. Sky Plane plot of the U.K. observations of the 2016 Oct. 9th occultation of UCAC4 513-051375 by Adorea, from www.euraster.net.

We were also concerned about the weather, as PNG is right under the Intertropical Convergence in October; see Fig. 4 for a typical satellite image. The first night we arrived, it was overcast with rain all night. But the locals said they often saw stars late at night. On the night of the event, it was overcast all evening, but the midnight IR image showed clouds thinner, and at 1:30am, we saw many stars. We left the motel and had time to set up equipment at two sites. Unfortunately, the northern station with a 120mm refractor failed to record the occultation, but it was seen on a monitor by teachers at the school where it was located. The southern attended station used a 10-in. "suitcase" telescope that had been completed by John Broughton in Queensland, where we visited about a week before. We wanted to use the large telescope to try to video record the close faint companion of Regulus, probably a white dwarf discovered in 2005 [1], during the 3s occultation. The approximately 12th-mag. companion is just above the arrow on the right side view of Fig. 5; Adorea was fainter, 14th mag., as it was almost on the other side of the Sun. Note Regulus' 8th-mag. visual companion 3' above and to the right of Regulus.

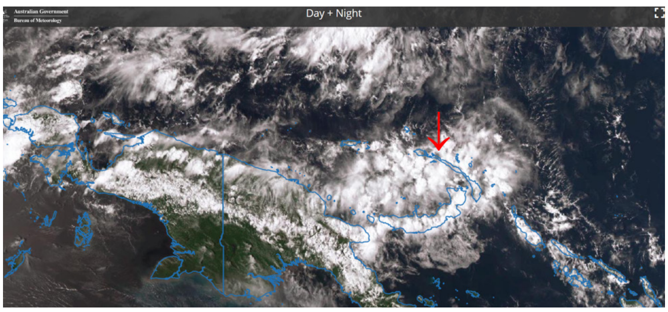

Fig. 4. A typical October Japanese weather satellite image of Papua New Guinea; the red arrow marks Kavieng. From the Australian Bureau of Meteorology.

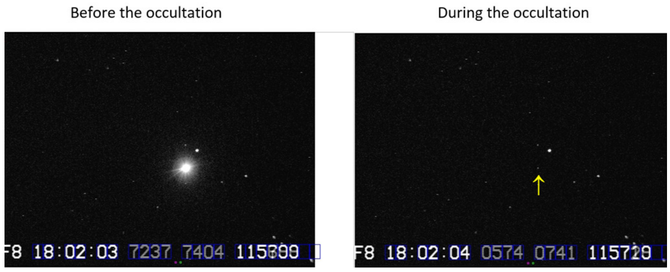

Fig. 5. Two frames from the Dunham video with a 10-in. telescope near the Ulul Plantation, New Ireland, PNG.

During the trip, the Dunhams also recorded an occultation by asteroid Lumen from the Glass House Mountains area of Queensland, attended the American Astronomical Society's Division of Planetary Sciences conference in Pasadena, Calif., and visited our son in Ann Arbor, Michigan, during Joan's 50th University of Michigan class reunion.

2017 November 21 and 28, Occultations by (543) Charlotte

At the end of November 2017, there were two remarkably similar occultations of 12th-mag. stars by the asteroid (543) Charlotte, with almost the same paths, shown in Fig. 6 and Fig. 7.

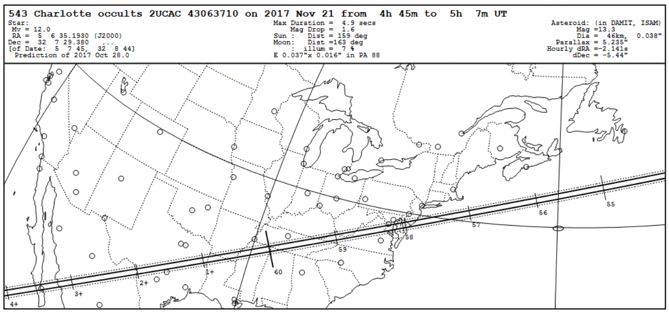

Fig. 6. Occult path map of the 2017 Nov 21 occultation of 2UCAC 43063710 by (543) Charlotte.

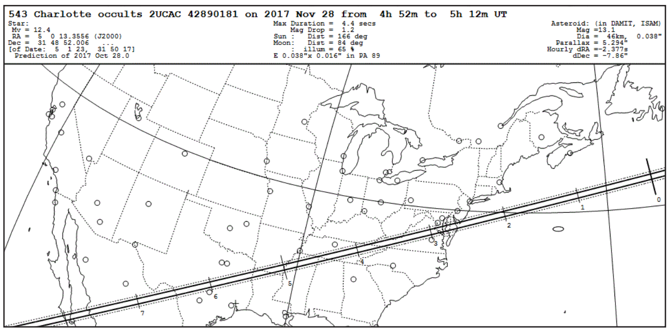

Fig. 7. Occult path map of the 2017 Nov 28 occultation of 2UCAC 42890181 by (543) Charlotte.

For the first occultation, the Dunhams planned to run 5 stations, starting at their home in Greenbelt, MD and extending south across the predicted path and the 1-sigma zones. At dusk, as David pre-pointed a 10-in. "suitcase" telescope on their back deck, he heard fire engine sirens becoming louder and looked up to the view in Fig. 8.

Fig. 8. November 21 UT, the house next door is on fire! Back and front yard views.

Since the fire hydrant is on the opposite side of our yard, fire hoses soon covered our driveway and front yard. About 10 large fire trucks completely blocked our street; it was obvious that we couldn't go anywhere for the occultation. Clouds moved in as well, covering the sky. But David had already pre-pointed the telescope on our back deck, so he decided to record, no matter what. The clouds thinned, and although the location was near the northern one-sigma limit, a 6.35s occultation was recorded, greater than the 4.9s maximum predicted. We had documented a large north shift, but since there was only one positive (see the sky plane plot in Fig. 11), we concluded that the shift was 0.8 ±0.5 path-width north, and since the geometry was so similar for the November 28th event, we recommended that observers be within this range. Maps showing this observing range, marked by two dark gray lines, were generated using the Google Map for the event on Derek Breit's Web site at http://www.poyntsource.com/New/Global.htm and posted by Brad Timerson on his North American asteroidal occultation page at http://www.asteroidoccultation.com/observations/NA/ . An example is shown in Fig. 9. The path also crossed Iberia, so a map for that area was generated and observers on the Planoccult e-mail list were notified.

Fig. 9. The improved prediction for the possible area of the Nov. 28th occultation, based on the Nov. 21st observations, is shown between the two dark gray lines on this map of part of the Mid-Atlantic region. The nominal (uncorrected) predicted path is between the two dark blue lines, 46 km apart, with the light green line being the center and the red lines being the 1-sigma limits.

For the Nov. 28th event, the Dunhams hoped to deploy 6 stations, and managed to set up 5, as shown in Fig. 10.

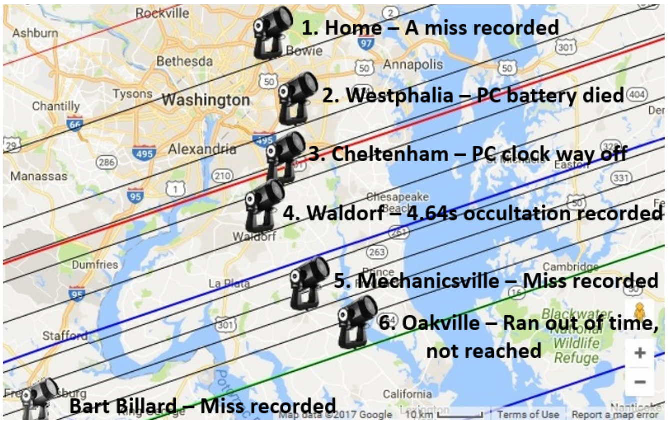

Fig. 10. Occult Watcher Google Map showing results of the Dunham's multi-station deployment for the Nov. 28th event.

The failures at Dunham Stations 2 and 3 were unfortunate as they most likely would have been positive. The occultation was also recorded by Michael Skrutskie at the University of Virginia in Charlottesville, and by Johnny Barton in Robinson, Texas. Clouds apparently prevented observation from Iberia. The results of both occultations are shown in Fig. 11. The scales for the two events are slightly different, but it is obvious that the shifts from the prediction were nearly identical for the two events. The ellipse fitted to the better-observed Nov. 28th event is 55 by 42 km.

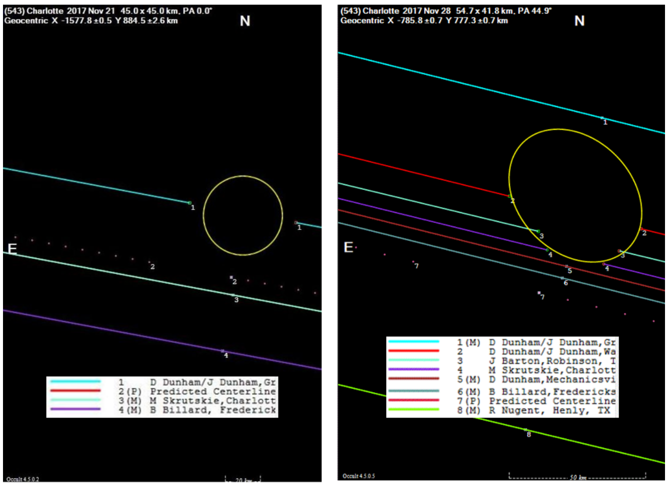

Fig. 11. Occult 4 sky plane plots of the observations of the two occultations, Nov. 21 on the left and Nov. 28 on the right, by Brad Timerson.

Occultations by (50) Virginia

For the Charlotte occultations, the direction of motion of the asteroid changed very little during the week between the two events, so it was good enough to just consider the shift perpendicular to the predicted path. During the last several months, there have been several occultations by (50) Virginia, but more widely separated in time. Thus, it was necessary to consider the two-dimensional shift in the sky plane, corrections in both the RA and Dec directions, rather than just a shift perpendicular to the path. The asteroid first attracted our attention on 2017 November 17th when the 100-km asteroid occulted 12.7-mag. UCAC4 544-27739 in a path crossing the USA from Delaware to southern Arizona. The Dunhams hoped to deploy a few stations to record the event, but extensive clouds in the evening prevented setting up any remote stations. They managed to find a site near Trappe, Maryland, only a few km south of the predicted central line, where the sky was clear and an occultation was timed. But it lasted only 3.31 seconds, compared with the 24.7 second duration expected for a central event. So there was a significant path shift. The occultation was also timed by Paul Maley in Arizona, and Mike Strutskie had a miss at Charlottesville, VA, so we soon knew that the path shifted north, as shown in the sky plane plot of Fig. 12. Curiously, the best-fit ellipse shown in Fig. 12, with dimensions 72 by 50 km, has a mean diameter of only 60 km, much less than the 100 km expected. Is the asteroid much smaller than predicted, or is it just an artifact of an unusual shape, with much more of the asteroid farther north than the elliptical fit would suggest? The answer would have to await future, better observed occultations by the asteroid.

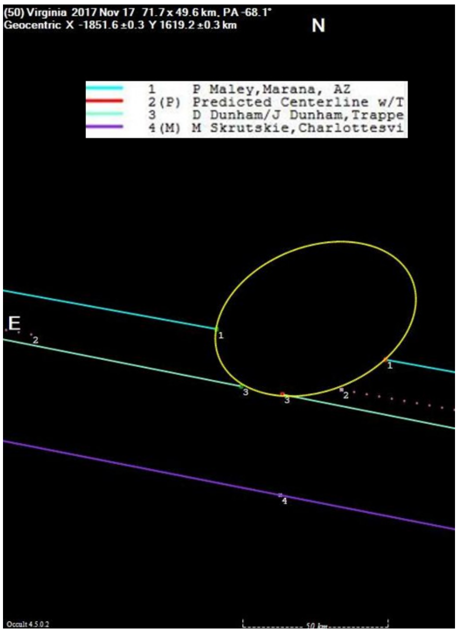

Fig. 12. Sky plane plot of the observations of the 2017 November 17th occultation of UCAC4 544-27739 by (50) Virginia.

Other occultations by Virginia were observed in 2017 on Nov. 30 (Switzerland) and Dec. 21 (Arizona), but each of these were relatively short chords seen from only one station, so nothing could be inferred about the asteroid's size from them. On 2018 February 7, a very favorable occultation of an 11.0-mag. star was predicted to cross southern California and central Arizona. Virginia's motion was in a direction about 70° different from that of the Nov. 17th occultation, but the corrections determined from Fig. 12 for that event, 10 km to the north and 45 km to the west, were applied to the prediction, showing that on Feb. 7, the path would likely shift about 40 km to the north. We expected the path to be about 100 km wide, but with some uncertainty in the shift due to only two chords for the Nov. event, we plotted the area of interest as 120 km wide, as shown by the dark gray lines on the map of Fig. 13.

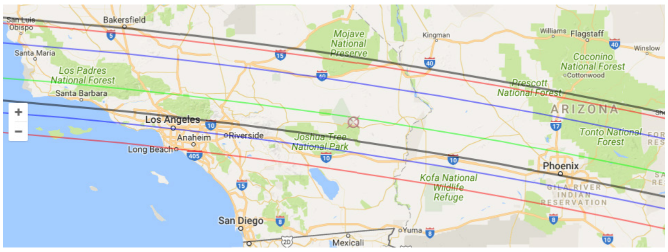

Fig. 13. The improved prediction for the possible area of the Feb. 7th occultation, based on the 2017 Nov. 17th observations, is shown between the two dark gray lines on this map of the southwestern USA. The nominal (uncorrected) predicted path is between the two dark blue lines, 100 km apart, with the light green line being the center and the red lines being the 1-sigma limits.

The weather was favorable for the occultation. Knowing from Occult Watcher that most of the observers, mainly in the Phoenix area, would cover the southern half of the path, the Dunhams decided to deploy 6 stations across the northern half of the zone. This worked very well; one of their stations failed, the northernmost (attended) one had a miss, and the other 4 were positive. Including the results of the many other observers made it the best observed asteroidal occultation in North America so far this year; see Fig. 14. The occultation contacts are fitted well by a 101 by 90 km ellipse, for an average diameter of 95 km; this answered the question posed earlier, showing that the smaller size from the 2017 November occultation must have been due to the only two chords from that event, and a shape significantly different from an ellipse; there is no shape model yet for (50) Virginia.

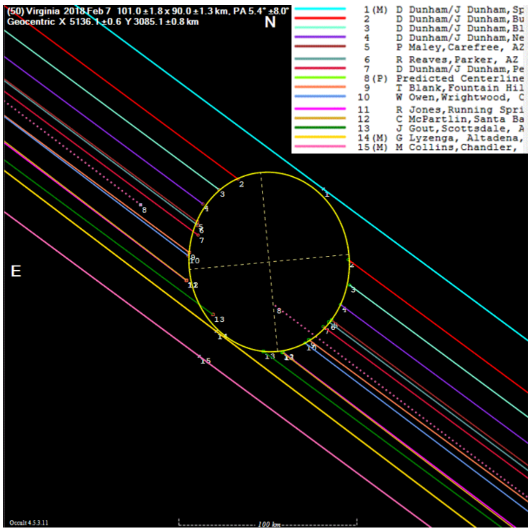

Fig. 14. Sky plane plot of the observations of the 2018 February 7th occultation of UCAC4 548-015983 by (50) Virginia.

Also from Fig. 14, the sky plane offsets from the nominal prediction can be determined more accurately than they could from the Nov. 17th event, since for the latter, the real shape must have been non-elliptical. They are 2 km north and 36 km west. These were applied to the predictions for two more occultations, in early May. The bright (mag. 9.9 star) event on May 6th was attempted in Michigan, but defeated by thin clouds and twilight; the clouds were much thicker over the path farther to the east, from Ohio to New Jersey. The May 4th occultation of 11.3-mag. TYC 1356-00856-1 in the southwestern USA was more successful, as shown by the sky plane plot shown in Fig. 15; it confirmed again the relatively large size of the asteroid, and the south shift of the path that occurred, was only a little larger than the 5 km predicted from the Feb. 7th event offsets. We thank the three observers of the May 4th occultation, for quickly informing the Dunhams of their results, so that the stations in Michigan could confidently be placed for the ill-fated May 6th event.

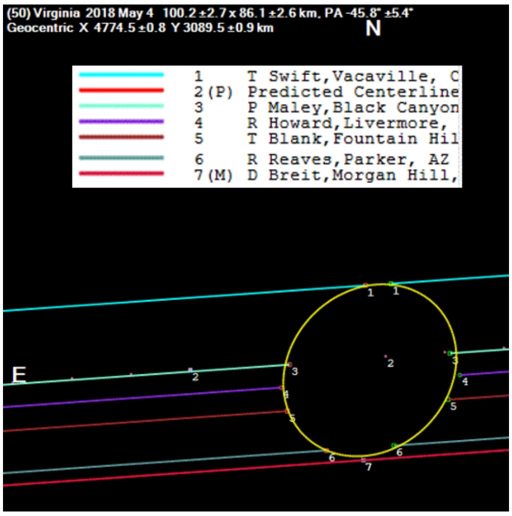

Fig. 15. Sky plane plot of the observations of the 2018 May 4th occultation of TYC 1356-00856-1 by (50) Virginia.

Other Occultations

We have been watching for other possibilities. For example, on April 10, there was a good occultation of a 10.5-mag. star by (424) Gratia with a predicted path extending from northern Virginia to southern British Columbia. On March 23rd, an occultation by the same asteroid was observed in Japan from 12 stations distributed well across the actual path; they showed that Steve Preston's ephemeris for the asteroid was very accurate so that no shift was expected on April 10. Unfortunately, bad weather prevented any observation of the April event. On April 21, an occultation of an 11.6-mag. star by the large asteroid (130) Elektra was observed from over 40 stations in western Europe, the best-observed asteroidal occultation so far this year. Eric Frappa posted the results quickly at http://www.euraster.net/results/ where we were able to use them to improve the prediction for an occultation by Elektra that occurred in North Carolina on May 1. The interesting results from these two successful events will be published in a future issue of JOA.

Conclusions

An occultation by (543) Charlotte was observed from two stations in Switzerland on 2017 October 14, but I did not know about that, or if the observations would have indicated the north shifts that we observed in the USA in November. Whenever an observer or regional coordinator notices a large shift from a prediction, we want to know about it, so that observers of future occultations by the same object can better position themselves, or those in the actual path area alerted, to obtain better observations, as we have demonstrated with Charlotte and Virginia. So far, we've just used the IOTAoccultations and Planoccult list servers to notify observers of expected path corrections. Another mechanism, such as a dedicated Web site, or perhaps Occult Watcher, might be more effective.

When the direction of motion between two events is less than about 10°, which is usually the case when they are two weeks or less apart, then we can just use the observed shift perpendicular to the path, as was done for the Charlotte events. But sometimes this is not the case, when the asteroid is near a stationary point. In those cases, and in general across most of an apparition, at least for about six months, sky plane delta-RA, delta-Dec corrections are effective, as shown by the (50) Virginia occultations. But these won't work from one apparition to the next; in those cases, it's necessary to improve the orbital elements, and consequently the ephemeris, of the asteroid by using the results from three or more well-observed past occultations, preferably spread over two or more apparitions. This might be done with the observations of (50) Virginia in 2017 and 2018 described above, but also considering the three other past observed occultations by the asteroid, in 1991 Dec. 31 (Germany), 1997 Jan. 22 (Poland), and 2016 May 20 (Japan). Unfortunately, each of those earlier events was observed from only one station. In any case, just recently (end of May), Dave Herald updated all of the astrometric data from past observed occultations, using Gaia2 data. This should help the predictions for those asteroids that have three or more past observed occultations. A similar effort has been done by the Lucky Star Project, to improve the predictions for occultations by Centaurs and TNO's, with the help of past observed occultations by those objects. This has already resulted in improved predictions for occultations by Chariklo, Quaoar, and Pluto. Hopefully soon, someone will figure out how to use the Gaia DR2 positions of the some 14,000 asteroids that have been observed by Gaia, to generate accurate orbital elements for most of the asteroids, for which we are generating predictions. After that, the asteroid ephemerides should become nearly as accurate as the star positions and shifts from the predictions should become a thing of the past; then we shouldn't have to worry about corrections like those described in this article. But that has not happened yet, and there will be new challenges to accurate predictions, including where the path edges are, based on available shape models.

We are grateful for the efforts by all of the observers who contributed observations of the occultations mentioned above.

References

[1] D.R. Gies et al., A Spectroscopic Orbit of Regulus, Astrophysical Journal, 682: L117-L120 (2008).

PS: Discussions are now in progress with the asteroidal occultation regional coordinators, to try to implement some of the ideas described above. In addition, Dave Herald and Steve Preston are working together, to improve the asteroidal orbital elements, and resulting ephemerides for predictions, using the Gaia DR2 asteroidal observations, and the many past observed occultations, using the Gaia DR2 data for the stars. Both efforts have run into some issues which we hope might be resolved before long, to give more accurate predictions for many of the asteroids.

Beyond Jupiter

The World of Distant Minor Planets

The sheer number of these minor planets is huge. As of September 2018, the Minor Planet Center listed 781 Centaurs and 1936 TNOs. In the coming years, JOA wants to portray a member of this world in every issue; needless to say not all of them will get an article here. The table shows you where to find the objects presented in former JOA issues. (KG).

No.	Name	Author	Issue
5145	Pholus	Konrad Guhl	JOA 2 2016
8405	Asbolus	Oliver Klös	JOA 3 2016
10199	Chariklo	Mike Kretlow	JOA 1 2017
20000	Varuna	André Knöfel	JOA 2 2017
28728	Ixion	Nikolai Wünsche	JOA 2 2018
54598	Bienor	Konrad Guhl	JOA 3 2018
60558	Echeclus	Oliver Klös	JOA 4 2017
90482	Orcus	Konrad Guhl	JOA 3 2017
120347	Salacia	Andrea Guhl	JOA 4 2016
136199	Eris	André Knöfel	JOA 1 2018

In this Issue:

(136472) Makemake

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ABSTRACT: Since 2016 JOA publishes portraits of objects beyond Jupiter's orbit. This short communication on the main Kuiper belt object Makemake covers the discovery, its properties and the role stellar occultations have played in the exploration of Makemake in the past and future.

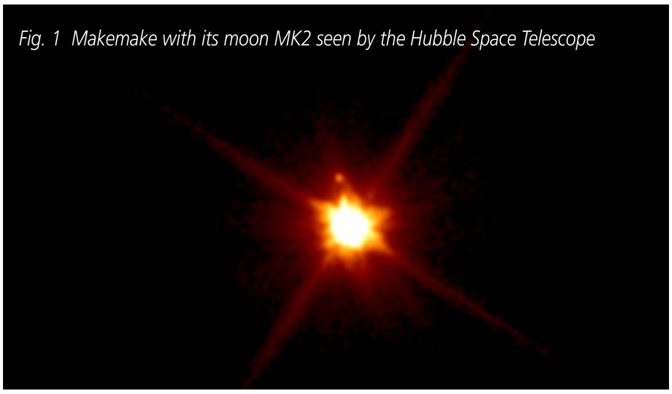

Fig. 1 Makemake with its moon MK2 seen by the Hubble Space Telescope

Discovery

Makemake was discovered on 31.03.2005 by a team led by Mike Brown at Palomar Observatory and was announced to the public on 29.07.2005 [5]. It was discovered in the same period as two other large TNOs: Haumea and Eris (Fig. 1).
It has 1/5th of Pluto's brightness and is therefore the only other object Clyde Tombaugh could have discovered in his search for Trans-Neptunian objects (apart from Pluto). The fact that it was discovered only after several fainter objects is attributed to its high ecliptical orbit inclination of 29 degrees. The search for new objects was conducted at the time near the ecliptic because discovery chances were seen as being much higher [5].
Makemake is the fourth biggest TNO after Eris, Pluto and 2007OR10. It is a dwarf planet like Pluto (Fig. 6) and probably the largest Kuiper belt object with a diameter of 2/3rds of Pluto.

Name

The new object received the provisional name 2005 FY9 after the dicovery was made public. The discovery team called it "Easterbunny" because it was discovered around Easter.
To preserve the relationship with Easter, the final name Makemake was chosen. It is the creator of humanity and fertility in the myths of the Rapa Nui people of the Easter Islands (Fig. 2).

Fig. 2 Makemake in the centre shown with two birdmen

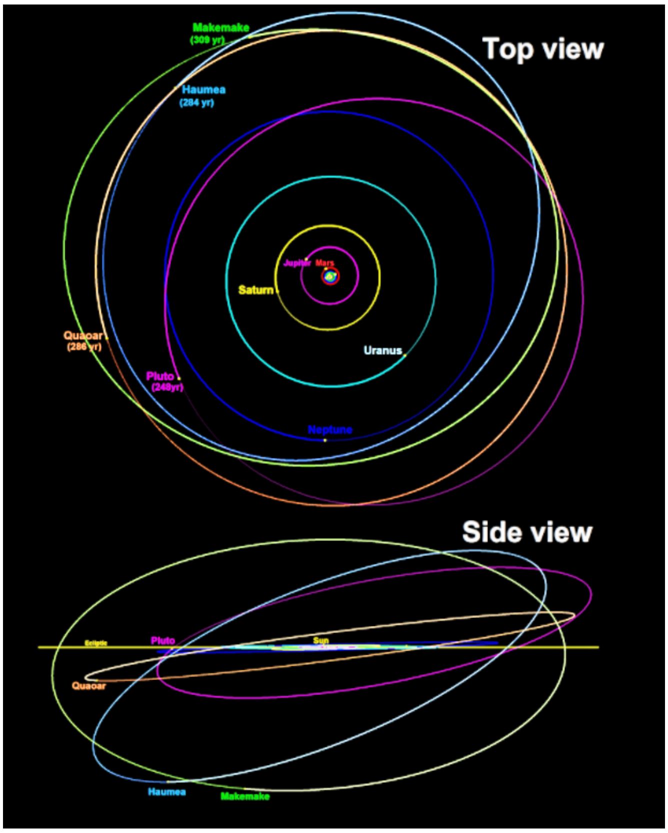

Fig. 3 Makemake's orbit (green track)

Orbit

Makemake's orbit is very similar to Haumea (Fig. 3). Currently it is approaching its aphelion in 2033 in the northern constellation of Coma Berenices.
Its steep inclination of 29 degrees and the modest excentricity of 0.15586 makes it a typical member of the Kuiper belt (Fig. 4). With an average distance of 45.715 AU the orbit is stable and far enough from Neptune to remain stable over the lifetime of the solar system. Its orbital period of 309 years is larger than Pluto's (248 years) and Haumea's (283 years).

Size and Surface Physics

A stellar occultation of an 18th magnitude star in 2011 gave a diameter of 1434 x 1420 km [10]. It is fairly round and shows just a small rotational lightcurve amplitude (0.03 Mag) with a rotation period of 7.77 hours. Due to the low amplitude of the light curve it was assumed that we are currently looking at the pole region of Makemake [5].

However, the discovery of a moon with an orbit seen edge-on from Earth implies that we could actually see the equator of Makemake.
The surface of Makemake is red in the visible spectrum and shows absorption bands of methane and nitrogen. The high albedo of 81% implies that the surface is covered with ice which could give rise to a transient atmosphere when approaching perihelion. [5].

Spectroscopic studies carried out at the William Herschel Telescope in Tenerife have shown that the surface could be inhomogenuous. Most of

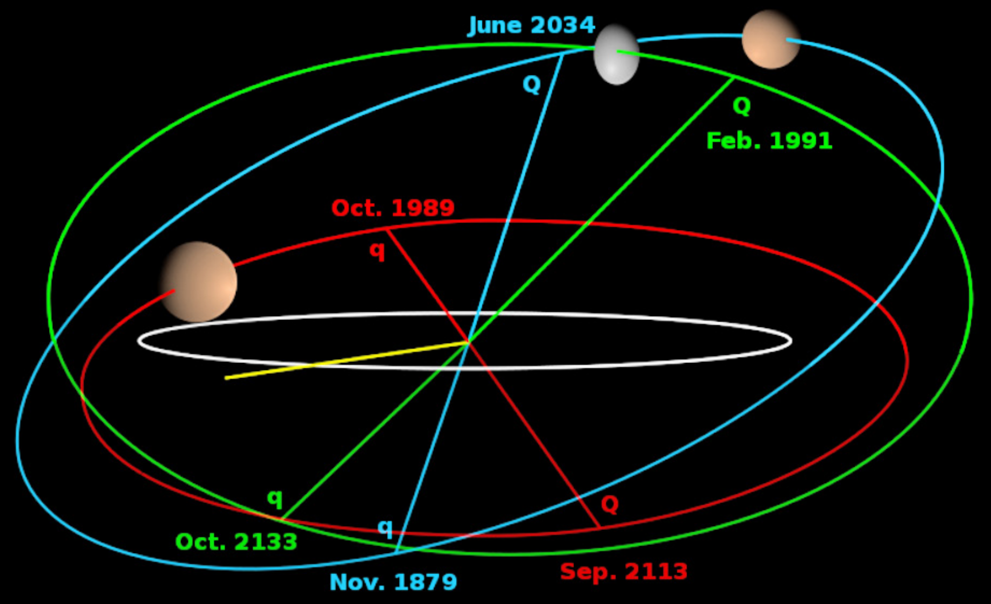

Fig.4. Orbits of MakeMake (blue), Haumea (green), contrasted with the orbit of Pluto (red) and the ecliptic (grey). The periphelia (q) and aphelia (Q) are marked with the dates of passage. The positions on April 2006 are marked with spheres illustrating relative sizes and differences in albedo and colour.

the surface is covered by methane and nitrogen ice (albedo 78-90%). Small dark areas (albedo 2-12%, covering 3-7%) seem to be scattered across the surface. They are attributed to tholins, photolysis products of methane by solar radiation [5].

The presence of nitrogen and methane ice makes its surface similar to Pluto's. Therefore the expectation was to see traces of an atmosphere just with a lower pressure. But during the stellar occultation on 23.04.2011, the light was abruptly blocked which puts an upper limit of 4-12 nBar on the pressure at its surface [10].

Compared to Pluto and Eris, Makemake's surface seems to be dominated by methane with only small amounts of nitrogen. Assuming that all dwarf planets started with the same nitrogen / methane ratio it was assumed that Makemake somehow lost most of its nitrogen during the last 3 billion years. The mechanism is still under discussion [5].

Moon

Makemake's moon was discovered in 2015 with the Hubble Wide Field Camera 3 (Fig. 1) and was announced to the public in 2016. The moon (called S/2015 (136472) 1, nicknamed MK2 by the discovery team) is estimated to be 175 km in diameter with an albedo of 4% (like charcoal) and an orbital period of 12 days. It is the only known satellite of Makemake. Moons are common with large TNOs: Pluto has five, Haumea has two and both Eris and 2007 OR10 have one [5].
Observations of MK2's orbit should lead to more precise mass measurements of Makemake in future.

Dwarf or Minor Planet

Makemake is the fourth biggest TNO after Eris, Pluto and 2007OR10 and is a dwarf planet like Pluto (Fig 6).
Makemake's discoverer M.E. Brown claims that he had introduced the term 'dwarf planet' and therefore sealed the fate of Pluto who lost its status as a planet in 2006 [2] : http://web.gps.caltech.edu/~mbrown/dwarfplanets/
The classification of Makemake is still a bit controversial. The Minor Planet Centre places Makemake among the main Kuiper belt population whereas the discoverer Mike Brown, David Hewitt and Marc Buie classify it near the scattered objects (Fig. 5) [5].

Occultations by Makemake

Stellar occultations by Makemake (like all other TNOs) are of great interest to the astronomical community. They could help to improve measures of diameter, shape, atmospheric data and lead to the potential discovery of more moons and even rings.

For 2018 no stellar occultations by Makemake have been announced. However, it is worth watching new predictions coming up on the excellent webpage of Bruno Sicardy's group [7]: http://lesia.obspm.fr/lucky-star/predictions/
The 2011 occultation has been recorded by three ESO observatories in Chile. A good film is available on youtube (showing the clear advantage of using a 3.5 m aperture instead of a modest 8"-12"): https://www.youtube.com/watch?v=TVJKaqp9xqQ

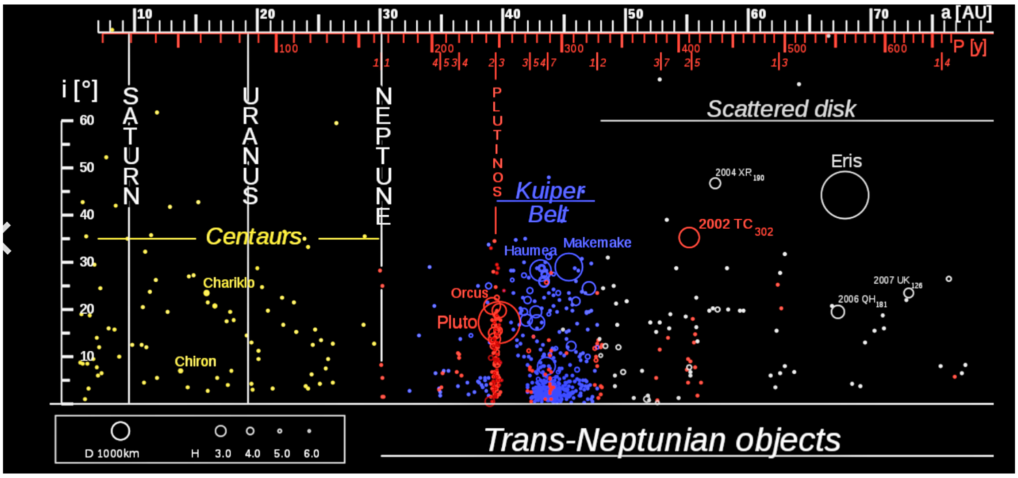

Fig. 5 TNO classification diagram

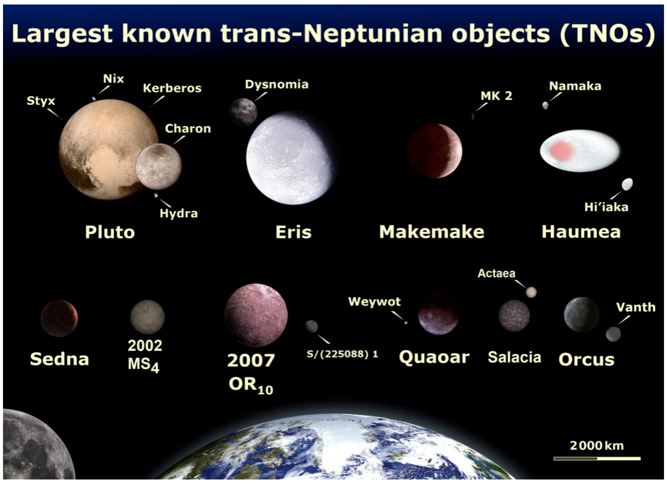

Fig. 6 Size comparison of TNOs

It shows steep drops and rises of the light curve implying the absence of a notable atmosphere.

Literature:

T. L. Lim; J. Stansberry; T.G. Müller (2010). "TNOs are Cool":
A survey of the trans-Neptunian region III. Thermophysical properties of 90482 Orcus and 136472 Makemake".
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International Astronomical Union (2008-07-19). "Fourth dwarf planet named Makemake" (Press release). International Astronomical Union (News Release - IAU0806).

Nature 491, 566–569 (22 November 2012): Albedo and atmospheric constraints of dwarf planet Makemake from a stellar occultation, J.L. Ortiz, B.Sicardy,[...], M.Emilio.

Lorenzi, V.; Pinilla-Alonso, N.; Licandro, J. (2015-05-01). "Rotationally resolved spectroscopy of dwarf planet (136472) Makemake". Astronomy & Astrophysics. 577. arXiv:1504.02350. Bibcode:2015A&A...577A..86L. doi:10.1051/0004-6361/201425575. ISSN 0004-6361

Web Links:

5. Makemake overview: https://en.wikipedia.org/wiki/Makemake
6. TNO overview: https://en.wikipedia.org/wiki/Trans-Neptunian_object
7. TNO predictions: http://lesia.obspm.fr/lucky-star/predictions/
8. occultation 23.04.2011: https://www.youtube.com/watch?v=TVJKaqp9xqQ
9. Mike Brown of Dwarf Planets: http://web.gps.caltech.edu/~mbrown/dwarfplanets/
10. Nature article on Makemake stellar occultation: https://www.nature.com/articles/nature11597

Picture Attributes:

Fig 1: public domain from: https://www.nasa.gov/feature/goddard/2016/hubble-discovers-moon-orbiting-the-dwarf-planet-makemake

Fig 2:GNU Free Documentation license from: https://commons.wikimedia.org/wiki/File:Makemake.jpeg

Fig 3: author TomRuen from Free Media Repositary:
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https://creativecommons.org/licenses/by-sa/4.0/

Fig 4: author Eurocommuter from
https://en.wikipedia.org/wiki/Makemake#/media/File:TheKuiperBelt_Orbits_2003EL61_2005FY9.svg

https://creativecommons.org/licenses/by-sa/3.0/

Fig 5: from Wikimedia Commons, the free media repository:
https://commons.wikimedia.org/wiki/File:TheTransneptunians_73AU.svg

Fig 6: from Wikimedia Commons, based on public domain NASA images:
https://en.wikipedia.org/wiki/File:EightTNOs.png

Journal for Occultation Astronomy

The International Occultation Timing Association's 36th Annual Meeting

Suffern, New York, April 20, 2018

by Richard Nugent, IOTA Executive Secretary

The 36th annual meeting of the International Occultation Timing Association was held on Friday April 20, 2018 at the Crowne Plaza Hotel in Suffern, New York. The meeting was kindly hosted by the organizers of the North East Astronomy Forum (NEAF) Imaging Conference. NEAF is the world's largest Astronomy Trade Show.

The meeting schedule and links to presentation files are located on the IOTA web site meetings page:
http://occultations.org/community/meetingsconferences/na/2018-iota-annual-meeting/

Attendees:
President Steve Preston, Vice President Dr. Roger Venable, Executive Secretary Richard Nugent, Drs. David and Joan Dunham, Bob Auburger, Bob Baer, Rick Bria, Al Carich, Steve Conard, James Curbo, Lynn Dorsey, Bob Dunford, Frank Dempsey, Timothy Guy, Ted Frimat, Tim Gong, Kevin Green, Chuck Herold, Roxanne Karmin, Mike Kentrianakis, Russ McCormick, John Moore, David Oesper, Luca Quaglia, Ned & Lynn Smith.

9:10 AM – Meeting Start

Vice President Dr. Roger Venable opened the meeting and welcomed everyone to the meeting. The attendees introduced themselves, described their backgrounds and current research.

Business Meeting

Treasurer Chad Ellington prepared IOTA's membership status; it was presented by Roger Venable. Currently there are 17 USA print subscribers plus 1 outside USA, 69 online subscribers, for a total of 87 subscribers. This is an increase of 20 members since last year. The IOTA email list sever, IOTAoccultations (IOTA membership not needed) has over 700 members.

The low number of paid members could be explained by the fact that IOTA predictions, methods, techniques and results are all online free. IOTA's Journal of Occultation Astronomy (JOA) is only available to paid members.

Expenses report: A summary of the year's bank balances are:

Starting Balance:	$10,496.81 2017 Sep 07 (Includes funds donated for a special asteroid satellite award)
Ending Balance:	$8,220.84 2018 Apr 11
Net Decrease in Balance:	$2,275.97
	The breakdown of this past year's budget is:
IOTA-VTI Royalties:	$72 (down $320 from last year)
PayPal Balance:	$1,872.78 (down from last year due to layout/printing costs finally paid for several back issues)
Major Expenses:	
JOA print cost:	$891
RunCam advance:	$1,300 (IOTA buys these cameras in bulk with the focal reducers/adapters and then sells them as a package)
Awards:	$412.75 (from last meeting-includes postage to foreign countries)

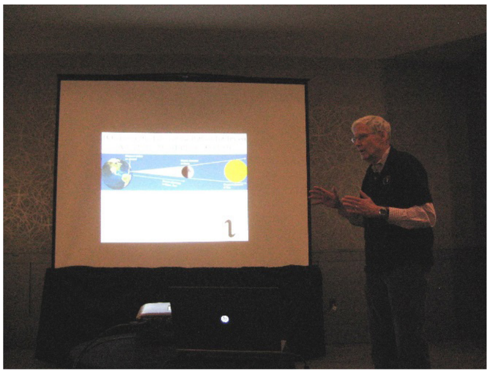
The JOA is currently being published on time. More articles are needed and people are encouraged to write them. The new password access for downloading the JOA is working.

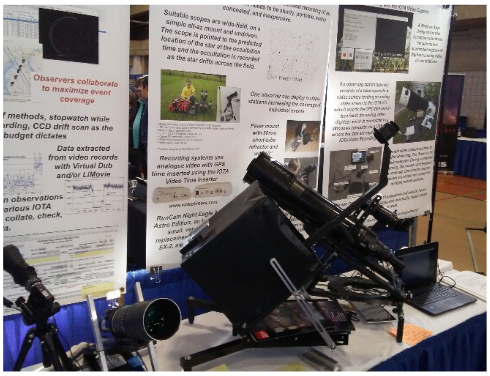
Technical Sessions

Brad Timerson (talk presented by Roger Venable) "7 months of Asteroid Occutations in North America". A chart was showed how the total # of North America asteroid observed events observed from 2007-2018. For 2018 to date: 176 positives, 420 misses, total = 596. Any observation, whether a positive or miss, is still an observation that has to be recorded and then plotted on a sky plane and then uploaded to the North America Asteroid Results page.

The next chart showed the number of chords attempted per observer. Through April 2018, there were 88 (1) chord observations, 44 (2) chord observations, 8 (4) chord observations, and events with more than 4 chord observations was 16. Next Roger showed the best observed events since the last meeting in September 2017 including comparisons to shape models. It was noted that Brad does a fine job of fitting chords to the shape models.

Roger talked about next year's "Sirius Occultation – 19 February 2019 by the 7 km asteroid 4388 Jurgenstock". Sirius is the brightest star in the night sky. The diffraction effects will make the event not appear instantaneous. Sirius's angular diameter is almost as large as that of





the asteroid. The path goes from Baja California to Canada. Southern Arizona will have Sirius at the highest altitude in the USA. Roger next showed events in which the occulted star is brighter than m = 8.0, including 633 Zelima occulting 4th magnitude iota Aquarii on the evening of September 6th along the east coast of the USA. He then showed events with asteroids having known moons, including the recently discovered moon around 113 Amalthea on March 14, 2017.

Dr. David Dunham spoke about the best graze events from the previous IOTA meeting in September 2017 through the end of 2018. He showed the results of the 2017 Thanksgiving evening graze he and Joan did with a 25% illuminated crescent moon. Their 10 events plotted had an excellent match compared to the LRO (Lunar Reconnaissance Orbiter) profile. An Aldebaran graze occurred on March 22, 2018 over the town of Nain, Labrador (population 1,424), near their airport.). A graze the night before the meeting on the way to NEAF occurred on April 19, 2018 of a 7.3 mag star, 19% Moon. They were thinking of doing the graze, but decided to skip it at the last minute due to clouds.

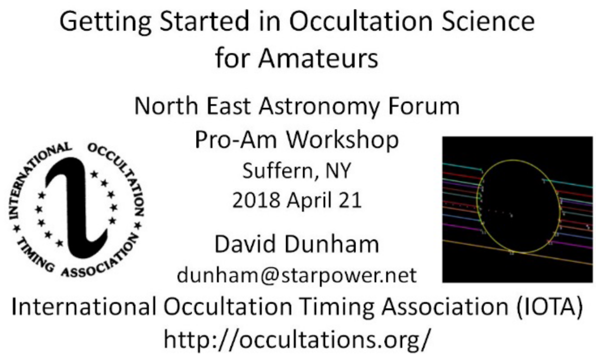
David showed (and offered at the NEAF conference) a handout of grazes occurring within 500km of the NEAF conference through July 26, 2018. The last Aldebaran graze in the current series will be on July 10, 2018 from Ontario over the Great Lakes through Wisconsin. The next Aldebaran graze series isn't until 2033.

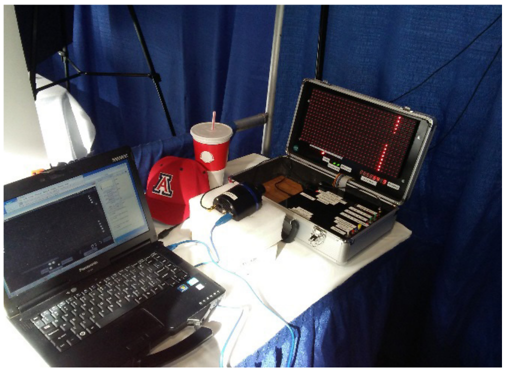
David then spoke about determining the "Edges of the Path of Totality for the August 21, 2017 eclipse (Historical Context)". This talk was given at the American Astronomical Society 231st meeting on January 9, 2018 in Washington, DC. David's first total eclipse was March 7, 1970 and he observed it from a short distance inside the south limit. He talked about historical attempts to measure the solar radius including data he analyzed from the 1715 and 1979 eclipses. He re-analyzed the data vs. predictions to see if there were any long term changes in the solar diameter. In determining the solar diameter, the Sun's edge needs to be defined. A major question in determining the Sun's edge is the wavelength analyzed.

Early IOTA efforts to measure the Baily's beads was by recording them projected on a screen. Alan Fiala in 1983 Jun 11 made the first video recording of the projected beads. The method has been refined over the years and time inserted video is currently the standard. Among the eclipses he discussed observations from: 1715 eclipse over England, the Jan 24, 1925 total eclipse southern limit over New York City and the June 11, 1983 eclipse over Java in Indonesia. The Feb 26, 1998 eclipse - he showed his results of the diameter- a reduction which averaged 0.20″ ±0.04″ as compared to the standard solar radius. He discussed the efforts to get citizen participation for the Aug 21, 2017 eclipse and the observations at the southern and northern limits including the use of smart phones. There weren't enough volunteers to reach the goals of determining historical accuracies of the solar diameter. He mentioned future eclipse plans will include the flash spectrum technique (first used by the Japanese in 1970) and video targeted at certain wavelengths.

David then showed a high definition DSLR color video by Fred Bruenjes from the Aug 21 2017 eclipse showing spectacular beads and prominences.

David next showed how he and Joan did the 369 Aeria Feb 18, 2018 occultation of the "A" component of eta Oph, (m = +3.0) double star over Australia. The prediction he made included taking into account the actual orbital motion of the barycenter (in addition to proper motion) which he made to 0.01″ accuracy. Along with John Broughton





near Queensland they set up a total of 12 stations (Broughton-7, Dunhams-5). In driving to the stations they did have issues with kangaroos !! Results - John had misses from all his stations and the Dunham's had 3 positives. He showed the video from station 3 that had a 2-sec event. David next presented "Improving Asteroidal Occultations Predictions using Recent Past Occultations by the Same Object", a talk he prepared for the 8th International Workshop & Eclipses at Istanbul, Turkey earlier this year. The Gaia satellite 1st release has provided over a million accurate star positions. The U.S. Naval Observatory combined these with Hipparcos and Tycho positions to provide better proper motions and this resulted in the UCAC5 catalog. Using recent asteroid occultation observations, this provides a very accurate position of the asteroid which can be used to refine the orbits for future predictions. They also attempted the Regulus/268 Adorea occultation. Luckily an Adorea occultation was observed from Great Britain earlier; this provided an updated accurate position of Adora to refine its orbit.

But...the event was in the tropics of Papua New Guinea that typically has bad weather. They were lucky, with Regulus in the clear during the 3-sec occultation; they recorded Regulus's 12th magnitude companion first discovered from spectroscopic data in 2005 Regulus.
He also mentioned the Gaia data release (DR2) planned for April 25, 2018 which will include positions from some 15,000 asteroids. Observers are encouraged to report observations of asteroid events to help refine orbits of future events of the same asteroid.

1:45pm Meeting continues – Breakout Sessions

This year's meeting has a different format from previous years. After the above business meeting and morning presentations, the group met in small "brainstorming" sessions to talk about recent developments in equipment, software and related techniques, plus discuss new ideas.

Some of the sessions were:

Joan Dunham demonstrated the IOTA's video capture method to a Windows 10 computer stick.

David Dunham discussed setting up remote (pre-pointed) telescopes and hardware. And he talked about several experiences setting up scopes at night including home owners and Police. He also talked about the issues with putting telescopes in luggage, dealing with airport security, leaving notes at remote stations for passerby's, etc. David demonstrated setting up the Orion 80 mm telescope plus John Broughton's paver mount and other equipment.

Other small sessions included demonstrating Limovie's features, selecting remote stations and video/timing capture using computers.

5:00 pm... the meeting ended and IOTA's NEAF volunteers moved equipment to Rockland Community College for IOTA's NEAF booth setup.

The minutes of IOTA's annual meetings are at:
http://www.poyntsource.com/Richard/IOTA_Annual_Meetings.htm

Fig 1 - Masthead of ON from 1974 - 1996 calligraphed by Raymond Franklin DaBoll, father of the first editor of the ON, Homer F. DaBoll [1].

Immerse Yourself in Occultation History – The Occultation Newsletter Heritage Project

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ABSTRACT: The Occultation Newsletter (ON), precursor of the Journal for Occultation Astronomy (JOA), was published by IOTA from July 1974 to October 2009. This project wants to make this valuable resource, compiled by the occultation community all over the world, accessible to beginners and veterans in occultation work and for historians as well.

Before JOA

For 35 years in 120 issues in 14 volumes, more than 2000 pages, the Occultation Newsletter gave predictions for upcoming occultations and reported observations by stations from all over the world. During the pre-internet times, the printed ON was *the* source of valuable information about occultations and was mailed by the postal service. Later issues were distributed as PDFs for download by the worldwide members of IOTA. For quite a while all the issues of ON have been freely available on the webpage of IOTA as downloadable PDFs [2]. Unfortunately, many digital copies are poor quality scans and are hard to read.

The Project

"The Occultation Newsletter Heritage Project" is an ongoing process to present all the issues as good quality readable PDFs with bookmarks and the facility for the reader to search the articles for specific terms. Added hyperlinks in articles are checked for their current availability and marked if these are broken.

The project started in January 2018 as a personal task by the author with the later volumes, which were previously published as digital files. So scans of printed issues were not needed.

Things Done and Things to Do

The bookmarks were incomplete or missing in most of the issues. Two versions of Vol 8. No. 2 were found, one with formatting issues but more readable than the other version. This issue was reformatted and marked as "Revised Edition" by the project. PDFs from separate sources presented different versions of Vol. 13 No. 1. A European version includes a report about ESOP XXV in Leiden, the Netherlands; the U.S. version comes without this article. In this case both editions are preserved. Some European issues showed incomplete graphics because of the conversion of the page size from U.S. letter format to DIN A4.

Colour came late to the ON. The first issue with a colour image was Vol. 9 No. 4. The cover shows the patch of mission STS-107 in memory of the crew of the space shuttle Columbia. If versions with graphics and images in colour were found these were preferred for the project. Unfortunately many hyperlinks added to articles are dead already in our fast-moving times. These links were marked in yellow as "Broken Link" to avoid any disappointment for the reader.

Assistance Needed

Scanning of the printed issues will take a lot of time. The author of this article has got the archived collection of ONs from the estate of the late President of IOTA/ES, Hans-Joachim Bode (Figure 2). Most of the issues are in good shape and ready to be scanned (Figure 2, 3). Unfortunately, the collection has some missing issues, especially from the early volumes. If you still have some printed copies from early volumes (especially Volumes 1, 5 and 6) and you would like to support the project, please contact the author for a list of the ones required and guidelines for scanning.

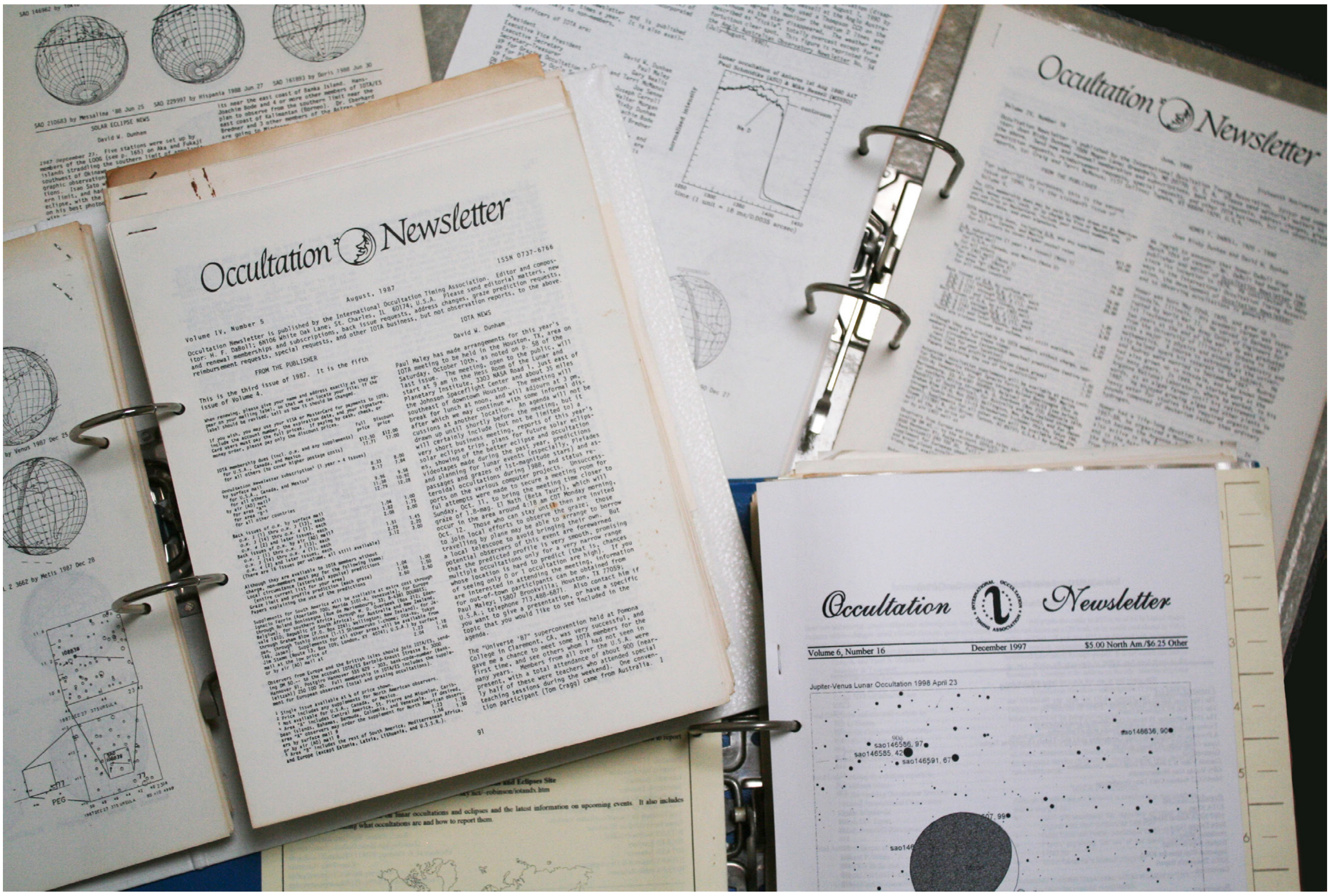

Fig. 2 Printed copies of ON from the estate of Hans-Joachim Bode, the late President of IOTA/ES.

Status of the Project

Volume 2 (except missing No. 11) and volumes 8 to 14 are now ready for download from the webpage of IOTA/ES (September 2018) [3]. More issues will follow in the next months. In the future these revised copies will replace the old files on the IOTA webpage. There is no time limit for completion of the project, because the work will be done in spare time.

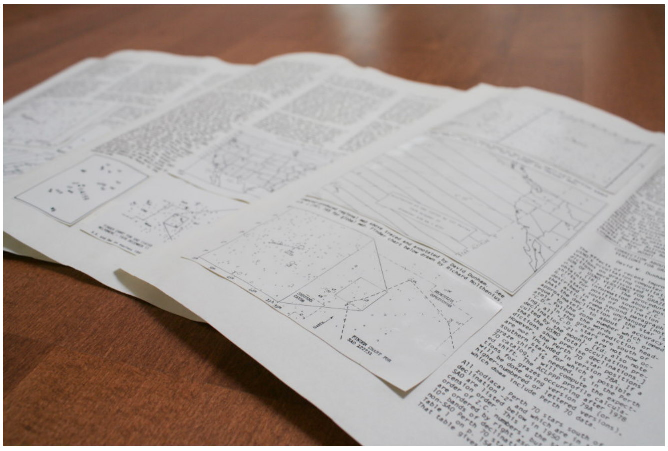

Fig. 3 Some paper ONs in the collection are original Journal copy, with charts and figures pasted onto the document pages.

References:

[1] DaBoll, Homer F., About the Name, Occultation Newsletter, Vol. 1 No. 2, (1974)

[2] IOTA Journal & Newsletter, webpage of IOTA, (2018)
http://occultations.org/publications/newsletters/

[3] The Occultation Newsletter Heritage Project, webpage of IOTA/ES (2018)
http://www.iota-es.de/on_heritage.html

Further Reading:

Craig, R. , Raymond Franklin DaBoll (1892–1982), The Encyclopedia of Arkansas History & Culture, (2016)
http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=3750

Journal for
Occultation
Astronomy

INTERNATIONAL OCCULTATION TIMING ASSOCIATION

IOTA's Mission

The International Occultation Timing Association, Inc was established to encourage and facilitate the observation of occultations and eclipses It provides predictions for grazing occultations of stars by the Moon and predictions for occultations of stars by asteroids and planets, information on observing equipment and techniques, and reports to the members of observations made.
The Journal for Occultation Astronomy (JOA) is published on behalf of the IOTA sections and for the worldwide occultation astronomy community.

The Offices and Officers of IOTA

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IOTA maintains the following web sites for your information and rapid notification of events:

http://www.occultations.org
http://www.iota-es.de

These sites contain information about the organisation known as IOTA and provide information about joining.

The main page of occultations.org provides links to IOTA's major technical sites, as well as to the major IOTA sections, including those in Europe, Middle East, Australia/New Zealand, and South America.

The technical sites hold definitions and information about all issues of occultation methods. It contains also results for all different phenomena. Occultations by the moon, by planets, asteroids and TNOs are presented. Solar eclipses as a special kind of occultation can be found there as well results of other timely phenomena such as mutual events of satellites and lunar meteor impact flashes.

IOTA and IOTA/ES have an on-line archive of all issues of Occultation Newsletter, IOTA'S predecessor to JOA.

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