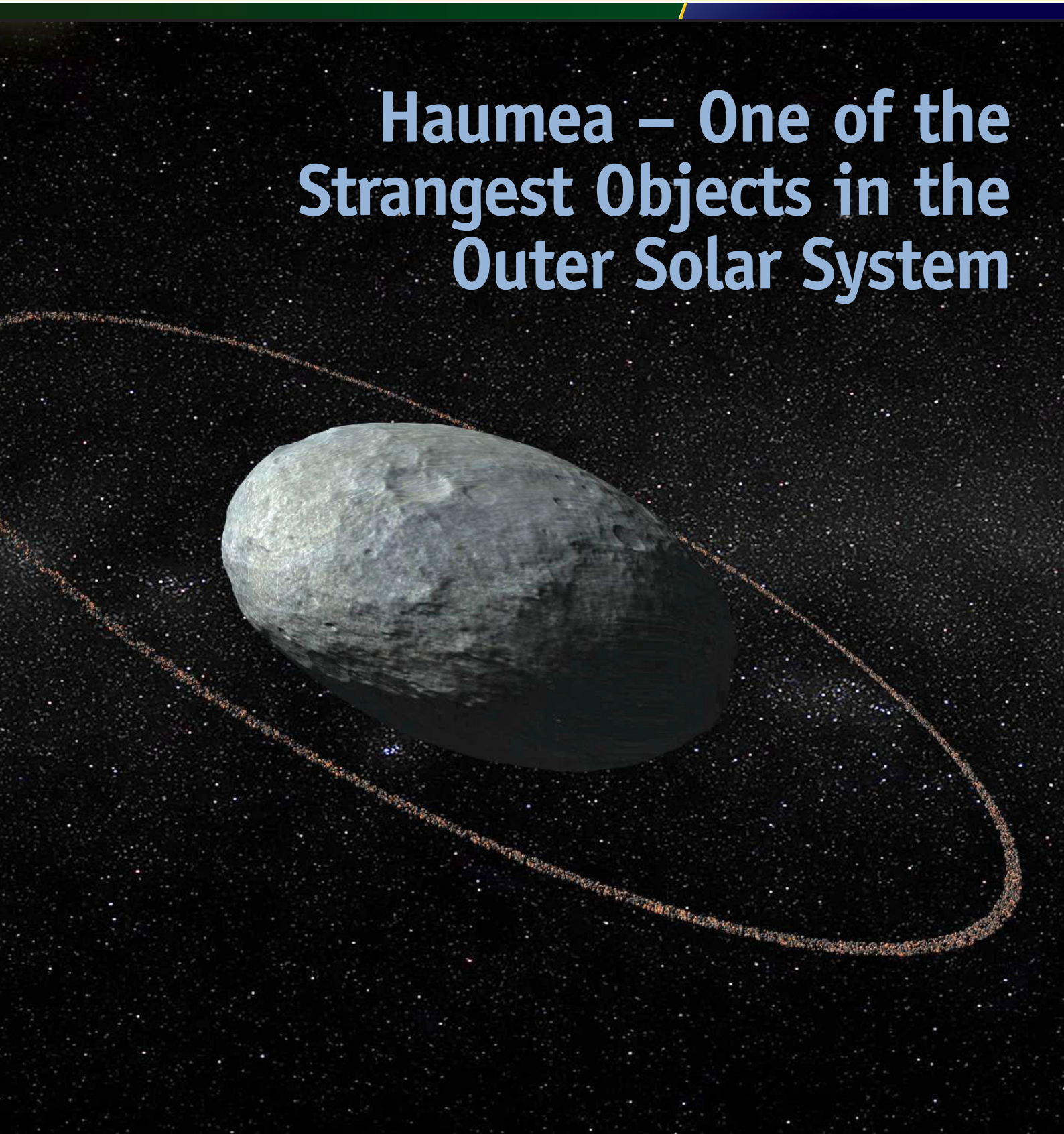
Journal for
Occultation Astronomy

Volume 7 · No. 4 2017-04

Haumea – One of the Strangest Objects in the Outer Solar System



Dear reader,

one of the most exciting occultations in 2017 is history now. On October 05 many stations in Europe and the U.S.A. made successful observations of a stellar occultation by Neptune's moon Triton. Several stations were able to record a central flash. The data from these positive observations will give us new insights about the atmosphere of this satellite far away. With this event, another pro-am collaboration was accomplished successfully.

Even more observers tried to measure this event in Europe, but just at this important night, the violent storm "Xavier" passed the northern part of Central Europe and made measurements for many stations impossible. A successful observation became a sort of lottery for my station in Germany at the outer boundaries of the storm. Low clouds and clear sky changed rapidly in the hour before the predicted time of occultation. Finally I lost this game. Twenty minutes of "Clouded-out" at the time of occultation were enough to spoil my observation. Needless to say the sky was clear again when I took my telescope back into the house. In the future our predictions of occultations will be more precise than ever with the availability of high precision astrometric data from upcoming data releases by ESA's Gaia mission. The main reason for unsuccessful observations will be dominated by the last unreliable factor for on-time-observations: the weather.

For this reason we need a good coverage of the path by observing stations, not just perpendicular to the path, but along the path too. Keep this in mind if you notice that your chord is occupied already at "Occult Watcher". Observe – you never know if the other station is clouded out. Two observations at the same chord is better than no observation at all.

Oliver Klös
Public Relations, IOTA/ES

JOA Volume 7 · No. 4 · 2017-4 $ 5.00 · $ 6.25 OTHER (ISSN 0737-6766)

In this issue:

Cover Photo

Illustration Credit: Instituto de Astrofísica de Andalucía

Haumea – one of the strangest objects in the outer Solar System has recently been found to have a ring. The object, named Haumea, is the fifth designated dwarf planet after Pluto, Ceres, Eris, and Makemake. Haumea's oblong shape makes it quite unusual. Along one direction, Haumea is significantly longer than Pluto, while in another direction Haumea has an extent very similar to Pluto, while in the third direction is much smaller. Haumea's orbit sometimes brings it closer to the Sun than Pluto, but usually Haumea is further away. Illustrated above, an artist visualizes Haumea as a cratered ellipsoid surrounded by a uniform ring. Originally discovered in 2003 and given the temporary designation of 2003 EL61, Haumea was renamed in 2008 by the IAU for a Hawaiian goddess. Besides the ring discovered this year, Haumea has two small moons discovered in 2005, named Hi'iaka and Namaka for daughters of the goddess.

Writing articles for JOA:

The rules below should be regarded while writing an article; using them will greatly facilitate the production and layout of JOA!

If your article does not conform to these rules, please correct it.

There are 3 different possibilities for submitting articles:

- pdf-articles (must be editable – these can be converted)
- unformatted Word *.doc-files containing pictures/graphs or their names (marked red: <figure_01>) at the desired position(s)
- *.txt-files must contain at the desired position the name of each graph/picture

The simplest way to write an article is just use Word as usual and after you have finished writing it, delete all your format-commands by selecting within the push-down-list "STYLE" (in general it's to the left of FONT & FONTSIZE) the command "CLEAR FORMATTING". After having done this you can insert your pictures/graphs or mark the positions of them (marked red: <figure_01>) within the text.

- txt-files: Details, that should be regarded
- Format-commands are forbidden
- In case of pictures, mark them within the text like <figure001> where they should be positioned

Important: Use only the end-of-line command (press ENTER) if it's really necessary (new paragraph, etc.) and not when you see it's the end of the line!

Provide the full name of all authors, their affiliation (if applicable) and either the full postal address and / or the e-mail addresses (at least for the corresponding author). Also provide an abstract to your paper. The abstract should not exceed 200-250 words and may not contain any citations.

Journal for Occultation Astronomy

CALL FOR OBSERVATION:
(284) Amalia Occults Two Stars in One Night!

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ABSTRACT: On 2017 Dec 04, minor planet (284) Amalia will occult two stars within 55 minutes. Both occultations could be observed from Europe and America. In the South of the U.S.A. both paths will be very close together. So observers have the chance to measure two occultations by the same asteroid from the same observing site in one night. Before these events, another occultation by (284) Amalia could be observed on 2017 Dec 01. European observers may measure two occultations by (284) Amalia from the same location within three days.

Prelude to the Double Event

On 2017 Dec 01, three days before the double event, (284) Amalia will occult 2UCAC 38031586, a 11.6 mag star. Occultation starts at 01:49 UT. The path will cross Kazakhstan, Russia, Belarus, Poland, Germany, Belgium, The Netherlands, France and southern England. At Western Europe the path will cover the same area as the second event on Dec 04. The shadow leaves the surface of Earth behind at 02:04 UT after passing central Florida and Mexico [1].

First Event on Dec 04

(284) Amalia will occult 11.9 mag star 2UCAC 38030731 in the constellation Taurus. During the occultation, the combined light of the asteroid and the star will drop by 2.24 mag to 14.00 mag for ~3.8 seconds. The occultation starts in Russia at 01:24 UT and crosses North Europe with Lativa, Sweden, Denmark, Great Britain, Northern Ireland and Ireland. After passing the Atlantic, the path covers the coast of South Carolina, southern Georgia and northwestern Florida. In Mexico the target area will be very low at the horizon. The shadow leaves Earth around 01:37 UT at the Pacific, just to the west of Mexico [2].

55 Minutes Later - Second Event!

About 55 minutes later (284) Amalia will have moved 35 arcsec at plane of sky and reaches the position of 2UCAC 38030719 (Mv 11.6 mag). This star is not a double star component of 2UCAC 38030731. Occultation starts at 02:18 UT at Kazakhstan and the path will cross Russia, Ukraine, Poland, Germany, Belgium, The Netherlands, France and the southern England before passing the Atlantic. This time the shadow will appear at the coast of the U.S.A. in Georgia at 02:30 UT and will leave the surface of Earth after passing Florida and Mexico [3]. Observers in the south of Georgia and the northwest of Florida may have a chance to measure both occultations of this night!

Different Profiles - Rotation of (284) Amalia

The *Light Curve Database* gives a rotation period of 8.545 h for the asteroid [4]. If we set the time of the first occultation on Dec 01 as reference point of the rotation, the asteroid will have completed 8.37 rotations until the first event on Dec 04. The profile will have shifted about 133 degrees and (284) Amalia will show a different profile compared to the one at Dec 01. In the night of December 04, Amalia will rotate about 39 degrees more around its axis between the two occultations. Therefore we get a third profile.

Previous Occultations

Occultations by (284) Amalia were observed four times. The first observation was made by European observers in 2004 with five positive chords, but three of these measurements were visual observations and a diameter of ~ 47 km was determined. Two Occultations in 2007 and one in 2016 gave a slightly larger diameter (51-56 km). The observations in the first days of December 2017 are a good chance to give us even more accurate data about the shape and size of (284) Amalia.

Prepare Your Observations

Please check for any updates of the prediction by Steve Preston, IOTA, in the days before the occultations. We all know: predicted paths may shift!
Derek C. Breit, IOTA, provides useful maps, tables and star charts for your preparations [6]. Links are given at References below.

References

[1] Preston, S. 2017, Prediction for Occultation (284) Amalia, 2017 Dec 01, 01:56 UT

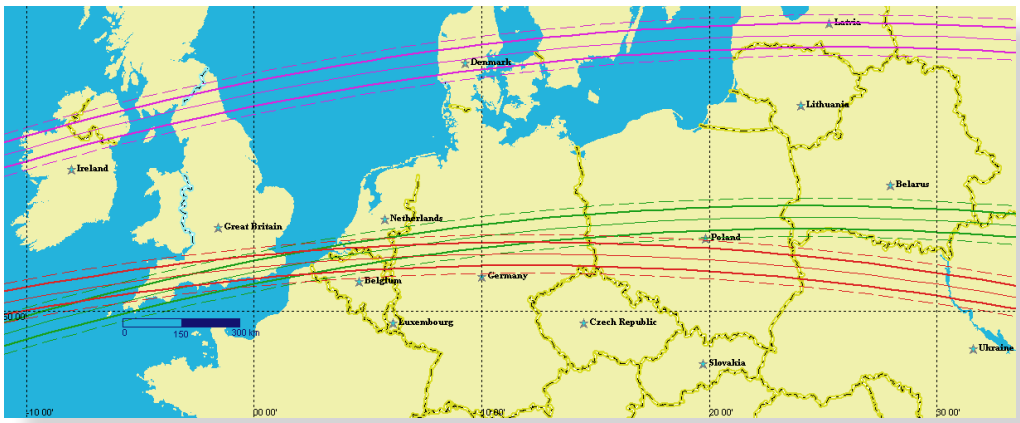
[2] Preston, S. 2017, Prediction for Occultation (284) Amalia, 2017 Dec 04, 01:30 UT

[3] Preston, S. 2017. Prediction for Occultation (284) Amalia, 2017 Dec 04, 02:25 UT

[4] Warner, B.D., Harris, A.W., Pravec, P. 2009. Icarus 202, 134-146. Updated 2017 Sep 11.

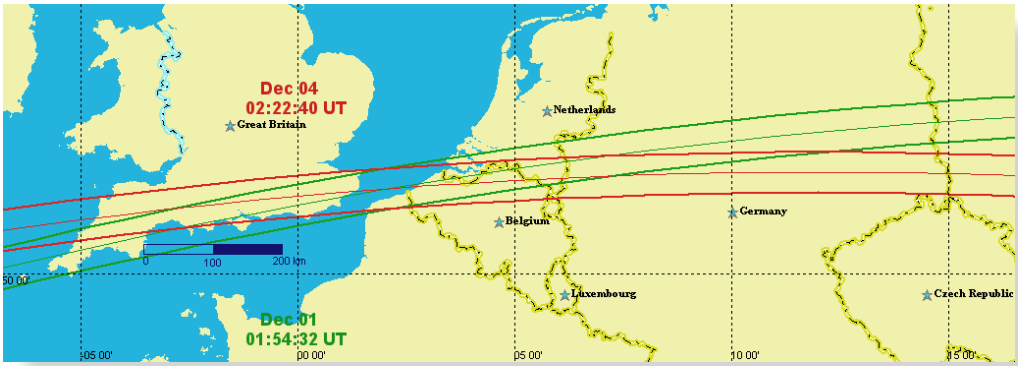
[5] Herald, D. 2017. Occultations by (284) Amalia were observed four times [5]. Database of Observed Asteroidal Occultations, Occult V4

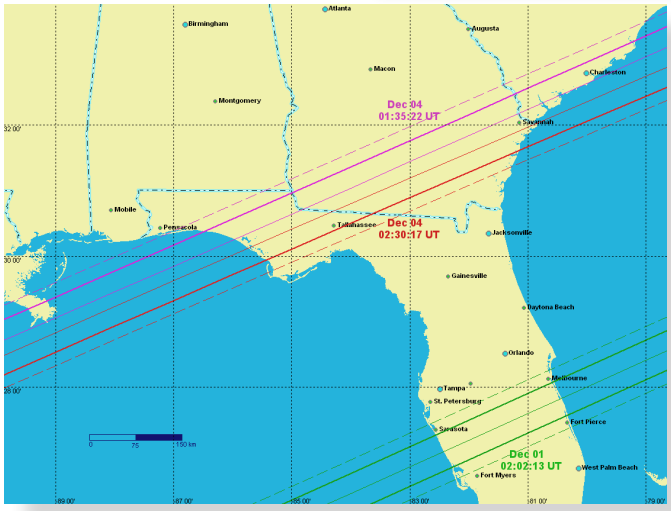
[6] Breit, D.C. 2017. Current Global Asteroid Events



Overview of the three shadow paths by (284) Amalia in December 2017 in Europe.
Path on Dec 01 (green), first event on Dec 04 (pink) and second event on Dec 04 (red). The dashed lines are the 1-sigma-limits. Shadows move from East to West. (Prediction data: Steve Preston, IOTA, 2017 Oct 13)

Detail of crossing paths in Europe without 1-sigma limits. The centre lines cross at the English Channel. Observers in Germany, The Netherlands, Belgium, France and southern England have a good chance to observe two occultations by the same asteroid within three days. Expected occultation times are given for longitude 0° (Prediction data: Steve Preston, IOTA, 2017 Oct 13)





The three shadow paths in the U.S.A. The first occultation on Dec 01 (green) will be visible in the south of Florida, expected time of occultation is given for longitude W 81°. The two events at Dec 4 will cover southern Georgia and the northwest of Florida. The times of occultation are given for longitude W 83°. Only the centre lines and the northern lines (first event on Dec 4, pink) and the southern lines lines (second event on Dec 04, red) are shown to make the map easier to read. (Prediction data: Steve Preston, IOTA, 2017 Oct 13)

The shadows will pass Mexico too. The occultation on Dec 01 (green) and the first event on Dec 4 (pink) are hard to observe because the target areas will be low above the horizon. Only the centre lines and the northern lines (first event on Dec 4) and the southern lines (second event on Dec 04) are shown to make the map easier to read. Expected occultation times are given for longitude W 102°. (Prediction data: Steve Preston, IOTA, 2017 Oct 13)

The International Occultation Timing Association's North America 35th Annual Meeting

Western Nevada College / Jack Davis Observatory
Carson City, Nevada · September 9-10, 2017

The 35th annual meeting of the International Occultation Timing Association in North America was Saturday and Sunday September 9-10, 2017 at the Western Nevada College's Jack Davis Observatory. The meeting was kindly hosted by Observatory director Dr. Tom Herring. This location coincided with 2 asteroid events, 357 Ninina 10 Sep 2017 and 241 Germania 12 Sep 2017 both paths across northern Nevada.
The final meeting schedule, links to presentation files and You Tube videos of the talks are located on the IOTA web site presentation page: http://occultations.org/community/meetingsconferences/na/na2017/

Persons participating in the meeting on site and via internet conference:
On site attendees: President Steve Preston, Vice President Dr. Roger Venable, Executive Secretary Richard Nugent, Aart Olsen, Ted Blank, Dr. Ted Swift, Eleanor Swift, John Moore, Walt Morgan, Jerry Bardecker, Derek Breit, Dr. Rick Nolthenius, Dr. Marc Buie, Red Sumner, Bill Hanna. Observatory Director Dr. Tom Herring, Chris and Loreli Patrick, Danny Falla.

Internet Conference Attendees: Brad Timerson, Secretary Treasurer Chad Ellington, Drs. David and Joan Dunham, Tony George, Atila Poro, Steve Messner, David Herald, Ernie Iverson, Oliver Kloes, Bob Sandy, Chris Erickson, Barton Billard, Darrel Irwin, Esdert Edens, Bruce Krobusek, Art Lucas, John Newman, Lloyd Franklin, Mark Smith, Walt Robinson.

9:00 AM – Meeting Start

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

Business Meeting:

Treasurer Chad Ellington presented IOTA's membership status. Currently there are 18 USA print subscribers plus 1 outside USA, 48 online subscribers, total subscribers is 67 with a net decrease of 37 members since last year. Except for the small member increase in 2016, membership trend has decreased in the past 10 years. The IOTA list sever has over 700 members.
This low no. 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.

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

Starting Balance:	$10,416.06	2016 Jul 21 (Includes funds donated for a special asteroid satellite award)
Ending Balance:	$10,496.81	2017 Sep 7
Net Increase in Balance:	$80.75	

The breakdown of this past year's budget is:

IOTA-VTI Royalties:	$392	(down $104 from last year)
PayPal Balance:	$2,764.04	Up 1,049.28 from last year but layout/printing costs have not been paid for several issues

Expenses:

JOA print cost	consistent from last year
Web Service:	still donated
Awards:	paid for last meeting

The JOA it is getting further behind on schedule now 2 issues behind from 2015. 1 issue for 2016 and currently 1 behind in 2017. More articles are needed. The new password access for downloading the JOA is working, however many folks have trouble remembering passwords.

Walt Morgan presented the IOTA-VTI status report. IOTA receives a royalty for every unit sold. It was originally designed by Dave Gault and Tony Barry. Walt was the proprietor, with the late Sandy Bumgarner the engineer. Last year (July 2017) Walt transferred the operation to the new licensee Bob Aubuger in Owings Mills, Maryland. The website name is unchanged and Auburgers website name is now on very unit sold.

The key features of the IOTA-VTI version 3 are:

Powered by 12v DC (centre positive)
CCIR (PAL) or EIA (NTSC) compatible
Will work without a camera connected
LED to confirm that a camera is connected.
Internal sensitive GPS is standard
External GPS antenna available
Characters have a drop-shadow – viewable against say, the lunar bright limb
Comprehensive Data Quality Assurance system
Lithium battery give the unit a non-volatile memory
Licensed to IOTA to prevent untimely withdrawal
Price US$249-$292 (depends if you want an external antenna/serial dongle)+ shipping
Can be purchased at http://www.videotimers.com

Walt mentioned that the Li-ion battery in the unit has a useful life of about 3 years. Users are encouraged to check the bottom of the start up screen for battery warning message. If the battery fails, the units memory/almanac will be lost. Walt then showed a few error notification screens. The total IOTA-VTI sales through June 2017 was 484 units. Most all of the units have been bought by IOTA and "occultationists", including Marc Buie's RECON team. Total royalties paid to IOTA through June 2017 $3,535. Rick Nolthenius asked how long the unit updates following a leap second. Walt said it's done almost immediately. The best advice for using the IOTA-VTI is to run it for 15 minutes to clear all potential errors and update the almanac.

Dr. Joan Dunham (talk given by Ted Blank) presented some of the posters IOTA uses at the NEAF meeting and other venues. Several posters on boards designed by Ted were shown. Since boards are difficult to transport, Joan and David designed high quality material posters that could be rolled up and easily transported. These posters are used at NEAF, Alcon, St. Louis Eclipse Expo and the AAS eclipse meeting. Shortly the posters will be available for download for individual use at other venues.

Dr. Terry Redding (talk given by Steve Preston) presented the annual **Homer F. DaBoll** award and **David E. Laird** awards. The Homer F. DaBoll (1920-1990) award is given annually to an individual in recognition of significant contributions to occultation science. "Occultation Science" is limited to actual IOTA research: total and grazing occultations, asteroid occultations and solar eclipses. The David E. Laird award is given to people who have made significant contributions to occultation science prior to 15 years ago. Laird (1931-1968) was an organizer of grazing occultations in the Midwest USA in the early 1960's. Laird confirmed the existence of a giant impact on the Lunar far side. Unfortunately Laird suffered from Leukemia and died in 1968 at age 37. The Laird award was conceived to help "catch up" on awards to some older IOTA members.

Previous Homer F. Daboll awardees: 2007: Dave Herald (Australia), 2008: Edwin Goffin (Europe), 2009: Steve Preston (USA), 2010: Hristo Pavlov (Australia), 2011: Scotty Degenhardt (USA), 2012: Kazuhisa Miyashita (Japan), 2013: Graham L. Blow (New Zealand). 2014: Brian Loader (New Zealand), 2015: Gerhard Dangl (Austria), 2016: Derek Breit (USA)

Previous David E. Laird awardees: 2013: Hal Povenmire (Florida), 2014: Gordon Taylor (England), 2015: Bob Sandy (Missouri), Jean Meeus (Belgium)

This year nominations were received for both the Daboll award and the Laird award. The Committee's main objective in selecting an award recipient was to reach a consensus and not choosing someone by a majority vote. Eligibility for the award is for anyone who has made significant contribution to occultation science or for the work of IOTA and its goals. Persons not eligible are current IOTA Officers & the award committee. Candidates nominated are not required to have IOTA membership.

This year's Award Committee elected to give multiple Daboll awards to the IOTA regional coordinators in the USA, Europe, Japan, and Australia/New Zealand that maintain the IOTA regional websites. These dedicated people have worked tirelessly in maintaining the occultation sites in their region over many years. They are given recognition as the asteroidal occultation program would collapse without their involvement and hard work.

The recipients of the 2017 Daboll awards are:
Brad Timerson / USA, **Eric Frappa** / Europe, **Tsutomu Hayamizu** / Japan, **John Talbot** and **Steve Kerr** / Australia / New Zealand.

The 2017 David E. Laird went to **Walter Morgan,** for his for his over 60 Years of Active occultation work, leading, lunar graze expeditions, technical development for occultations and manufacturing the IOTA-VTI. Walt described his history with IOTA since the 1968 when he made is first occultation observation. He later became a "computor" making predictions for observers over 6 regions. Back in the early days Walt had to mail the predictions via the US Post Office and this typically cost $60 in postage per quarter!! Walt's dedicated work with occultation science over many decades was held in the highest regard by the IOTA community.

10:00 AM... End of Business Meeting. Technical Sessions Begin.

Dr. Marc Buie of the South West Research Institute (SWRI) talked about 3 recent TNO occultations:

MU20170603 – 2017 June 3, 12 systems deployed to Argentina near Mendoza and 13 systems deployed to South Africa near Cape Town,

MU20170710 – July 10, 2017 a faint m=+15.6 star across the Pacific (not attempted on the ground but done by SOFIA)

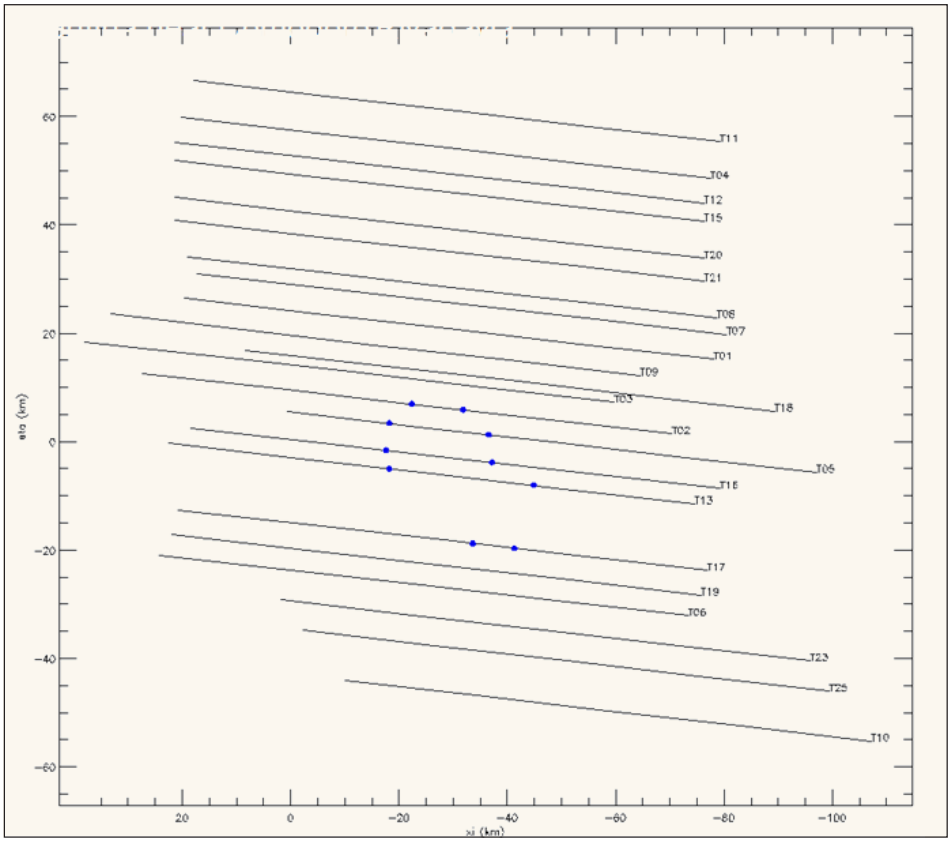
MU20170717 – July 17, 2017 across South America, m= +12.6 star. 25 systems deployed in Argentina near Comodoro Rivadavia.

Marc showed the ground track uncertainties computed by Hubble's observations and data from the recently released Gaia catalog. This resulted in ground path uncertainties ranging from 0.25 - 1.5 mas, where 1 mas ~ corresponds to 34 km on the ground.

For the June 3rd event, 22 portable 40-cm telescopes were deployed with CMOS detectors and GPS timestamps. 3 systems were deployed by UVa. The maximum occultation was 2sec and all observers got usable data. Preliminary analysis showed no diffuse material in the neighborhood of the object.

For the July 10th event observed by SOFIA, the goals were to search for diffuse or ring material +/- 30,000 km for stability region with a 45 minutes recording time window. Goal was to detect a solid body which meant being in a 1-2km zone. Preliminary results were 1) No diffuse material or rings seen, 2) no obvious solid body signature.

For the July 17th event detecting a solid body was a top priority. Marc set up the stations over a 4.5 σ range. Telescopes were spaced out 4.5 km from each other. Five chords were obtained with the longest duration = 1 sec, shortest 0.3 sec. The preliminary shape profile looked like this:



Preliminary shape profile of MU20170717. Blue dots represent the positive chords.

The shape interpretation could be:
Single object 34x20 km irregular shape
Contact Binary 34x19km
Close Binary 20km and 16km sizes respectively.

The shape profile estimates above are line of sight profiles only at the time of the event. The next major event is the occultation of MU20180814 by 2014MU69 SBP-170825 over South America and northern Africa. Planning is underway.

Marc next talked about the RECON (Research and Education Collaborative Occultation Network) team which was set up in 2013 to measure TNO objects > 100km. RECON covers the western USA with ~50 telescope systems setup over a 2,000 km north-south "fence" from Canada to San Diego. Each system consists of a Celestron C-11 SCT, a Mallincam video camera, IOTA-VTI and a laptop computer. RECON telescope systems are setup at schools and community colleges. Students (grades 4-12) setup the telescopes and make the measurements guided by adult team members. Typically 6-8 occultation observations are made each year. The first TNO occultation result, (229762) 2007 UK had a measured radius of 340 ± 10km was published in the Astronomical Journal (AJ) in 2015. Marc has periodic video conferencing for annual team meetings. RECON (www.tnorecon.net) has an email listsever, plus it's on Twitter @tno_recon and Facebook: TNORECON. Recon predictions are on the SWRI website. http://www.boulder.swri.edu/~buie/recon/reconlist.html

RECON Team members - in larger communities, there are always plenty of replacements when someone leaves, however this is not usually the case in smaller communities. When new people take over, re-training has to be done again.

Tony George presented the R-OTE Volunteer Group. Members are Tony George (Coordinator), Ted Blank, Darrel Irwin, Ernie Iverson, Greg Lyzenga, Chris Patrick, Ted Swift and Brad Timerson. The group goal is to support IOTA North America observer's observation reports of occultations using the R-OTE and PYOTE light curve analysis programs. Volunteers review observer csv files and reports and generate updated D and R times and error bars using R-OTE and PYOTE.

Tony next introduced a new light curve analysis program, PYOTE, Python Occultation Timing Extractor written by Bob Anderson. It's a stand alone program for analysis of occultation light curves. It can be installed in any operating system that

supports PYTHON code. It uses the same mathematical algorithms as R-OTE and it has been tested for both Mac and Windows operating systems. PYOTE has a maximum likelihood estimator to determine the best fit model light curves to the actual data. Sub-frame timing is included in the calculation of D and R times. A PDF file to guide users through the installation of the program (available on Brad Timerson's website):

MAC
http://www.asteroidoccultation.com/observations/NA/pyote-mac-revised-installation.pdf

Windows
http://www.asteroidoccultation.com/observations/NA/pyote-windows-revised-installation.pdf

PYOTE supports both Tangra and Limovie csv files. A nice feature is the "Start Over" button which allows bringing up all analysis scenarios the user has tried for comparison.....which are recorded. Also, a new excel program AstReport will account for camera delay corrections.
Tony next did a demonstration of how PYOTE works. The program is quite simple to use and stores the analysis, error bars, and D/R times for use in the report form. PYOTE is a work in progress and Bob Anderson will provide future developments. Future developments will include the uploading of light curve to the IOTA/VisieR database.

Aart Olsen presented "Timing in the Optical Domain". Aart's goal was to insert the time of the event right into the same image as the object being recorded. This method could work with any camera, including video cameras. The goals he set for this research: time displayed in every field, DIY capable and cheap enough for multiple deployment. The system is based on a Arduino microcontroller board. Cost is approximately $35 USD. Aart showed photos of the various components he uses.
A few demo frames showed the optical times right on the image. Aart needed to utilize a pattern of LED lights to get sub-second timing to match the GPS inserted time precisely. Another feature of the system is that one can interpolate between frames to extract times.

12:30-1:55 PM – Lunch Break

Ted Blank presented how to use portable GPS units to determine the centerline of the field for occultation events. Finding your position from the center line for your assigned chord is not necessarily easy without the Google internet maps. It turns out older (and newer) GPS units have an "Off Course" feature which was originally designed for use by ships at sea to tell them how far "off course" they were in their voyages. Ted showed how to get path coordinates from Occult or Steve Preston's prediction site and create a route file to be sent to your GPS device. The GPS units then display the centerline and output the "off course" perpendicular distance feature from the center line. On older GPS units, one can manually enter at least 2 lat/long waypoints to create a "center line track" of which the off course distance is computed and displayed.

Ted next presented his portable "stick-computer" occultation recording kit designed for the new RunEagle cameras to be used for his multiple deployments. The "stick" computer system was originally researched by Joan Dunham in 2016. The computer that records the video is the Lenovo Ideacentre Stick 300, which has no monitor. It uses Windows 10, 2 GB RAM, has a 32GB internal drive, and is powered by just 5v (not 12v). One of the reasons for using this 5v powered computer is that the RunCam Eagle camera also uses 5v and thus can be tied to the same power source. Ted showed images of the components connected. The only issue is focusing of the camera since the Leonova has no monitor. Ted uses a 7" LCD monitor (any monitor can be used) to check the camera's focus and then reconnects the camera back into the system.

Dr. David Dunham presented John Broughton's updated portable telescope design. John's old design was a 10" "suitcase" telescope. David showed pictures of the new 2016 design.

Note the video camera at the position where a secondary mirror would normally go. This provides a faster f ratio. One of the nice features is the altitude/azimuth adjustment system. The total weight 43.8 lbs, is within airline limits for air travel. A few minor changes were made for the 2017 design. The 2017 design is quite steady and compact! David offered some thoughts on manufacturing options. Perhaps with 100 pre-orders, a telescope manufacturer could offer a commercial design. The telescope also works as a general purpose visual telescope.

Offline **Roger Venable** worked with the attendees to assign sites for the 357 Ninina asteroid event later in the evening. Roger had previously checked out over a dozen sites to aid in the planning.

David Dunham next presented the occultation of Regulus by 268 Adorea 2016 October 13, by Paul Maley's expedition in Saudi Arabia. He described a few other Regulus events observed since 2005 including the totally clouded out event from March 2014 over New York and the Northeastern US States.

Brad Timerson presented a summary of 2016-2017 (through 8/31/2017) asteroid occultations. Brad showed a graph of yearly observations going back to 2006. There seems to be a trend this year (2017) of events with 3,4 and 5 or more chords which is a good thing. Individual events were shown with the 3-D models and as expected occultation chords fit very well with these models.

One event was 113 Amalthea on March 14, 2017 with the possible discovery of an asteroidal satellite companion. An announcement was made on the Central Bureau for Astronomical Telegrams (CBET 4413). Two observers Eisfeldt and Campbell had positive events outside the region of the other 5 positive chords indicating a possible asteroidal companion. IOTA North America offers an asteroid satellite discovery award, upon confirmation of the observation by independent means.

Dave Herald presented Global asteroid occultation results 2015-2017 (May). IOTA is now averaging 250 events/year, however 2016 had 280 events, likely due to the Gaia catalog release.
The No. of events by region for 2016 is:

Australasia	53
Europe	91
USA	107
Japan	27
Other	7
Late additions	15
Total	300

Double stars – 4 discovered in 2016, separations ranging from 10mas - 211mas. One double star, 2U31329020, (from the occultation by 695 Bella on 2016 Mar 19) had a separation of 10mas and PA = 57.0° which is below the resolution of Gaia.

He then showed 17 profile plots, many compared to 3D shape models. Most, not all profile plots had excellent matches with the 3D shape models.

Dave next presented "Volumes and Bulk Densities of 40 asteroids from ADAM shape modeling" as published in a paper in Astronomy and Astrophysics 2016 Oct 25. One question, why diameters are important? They're needed for occultation path limit predictions and spacing of observers. Densities can tell us much about composition and their origin. Densities are derived from mass and volume of the asteroid and thus occultation data helps out greatly with their sizes.

Masses are estimated from orbit deflections/pertubations and for contact binary systems by their orbital dynamics. Volumes of asteroids can come from size estimates from the chords from (hopefully) several occultations. He then discussed how complex the volume and mean diameter estimates can be to derive. Asteroid shapes can come from space craft imaging, direct imaging with large telescopes (poor resolution), radar imaging (mainly NEO's), multiple occultations, and light curve inversions. Light curve inversions can only be possible when there is a significant variation in its inclination of its axis of rotation as seen from Earth. The method is quite complicated but does provide a volume-equivalent and surface diameters of the model.
He then described some of the limitations with light curve inversions.

As an example, he showed volume, surface equivalent of 135 Hertha from 2008 compared to IRAS and Wise satellites plus the Asteroid catalogue using AKARI - (AcuA). Dave stressed the importance of such comparisons and that they should be done from multiple occultation observations. On average IRAS is the best at determining these parameters but in reality they are all equally reliable to within ±8% as compared to occultation and shape model.

Sunday 9 AM...Meeting Continues

Aniruddha Deshpande presented (with co-investigators Suhas Gurjar, Deepak Joshee, Sameer Godbole) from India presented "Occultation Activities in Jyotirvidya Parisanstha, India" (JVP). Their goal for occultation observations was to put together 10 sets of instruments and train observers for occultation observations for the 22 Kalliope event 24/25 Dec 2016. Paul Maley assisted with 8 video setups, pointing techniques and analysis of the data obtained. The path went over western and southern India. The team JVP had 16 stations planned out to observe the event and 8 stations had video. He then showed slides of several instrument setups. He showed the resultant profile which included 8 hits and 3 misses. Their shape profile matched well with the 3D shape profile. Their successful observation made the local newspapers in the area:

Global glow for astronomy clubs

SwatiShindeGole
@timesgroup.com

Pune: Amateur astronomy clubs in the city have been able to define the size and shape of an asteroid called 22 Kalliope and their observations have been recognised by the International Occultation Timing Association (IOTA).

On December 24, the asteroid travelled in front of a star identified as TYC 2430-01124-1 and the shadow of this asteroid was cast on earth. The shadow belt of the asteroid spread between Bhuj in Saurashtra to Nellore in Andhra Pradesh. To measure a planetary object, astronomers need to study its occultation.

According to the IOTA, an occultation occurs when a solar-system body passes in front of a more distant object, partially or totally hiding the more distant object, momentarily blocking its light.

Director of Nehru Planetarium Arvind Paranjpye said, "There is a simple way to make these observations. Sometimes these asteroids come directly between a distant star and the earth, just like a solar eclipse. The event can be seen over a narrow shadow path on the surface of the earth, this is

WHAT HAPPENED ON DECEMBER 24

A remote star, identified by number TYC 2430-01124-1, got occulted by a small asteroid called 22 Kalliope. One revolution around the sun takes it 4.97 earth years and it rotates around itself in 4 hours 8 minutes (Earth time). This asteroid travelled in front of the star on December 24, 2016, 3.26 am. The shadow of the asteroid was cast on certain places. Since the asteroid was travelling in space, its shadow was moving on the surface of the earth. Any one standing in the shadow belt of the star light would notice the star disappearing for a few seconds. This eclipse is called an occultation

Each line on the sides of the asteroid shows the occultation

occultation. When the asteroid comes between the earth and the star the star just blinks off for a few seconds. By carefully noting the duration over which the star disappeared and reappeared from different locations on the shadow belt, it is possible to determine the size and shape of the asteroid."

Amateur astronomy clubs in Pune set up observation stations at various locations on the Bhuj-Nellore belt and, by measuring the time of occultation accurately, they were able to infer the size – about 166km in diameter – and the asteroid's shape.

Suhas Gurjar, of Jyotirvidya Parisanstha (JVP) and one of the participants of the December 24, 2016 observation said, "There are a lot of lone observers, who note such events. Their work is very important as lone observation gives us an idea of minimum possible dimension of the asteroid. But simultaneous observation from a number of locations, gives one a better idea of the shape and size of an asteroid."

The JVP erected eight video stations between Pune and Aurangabad, three stations for telescope viewing and from one station through DSLR camera viewing to observe this event from different locations.

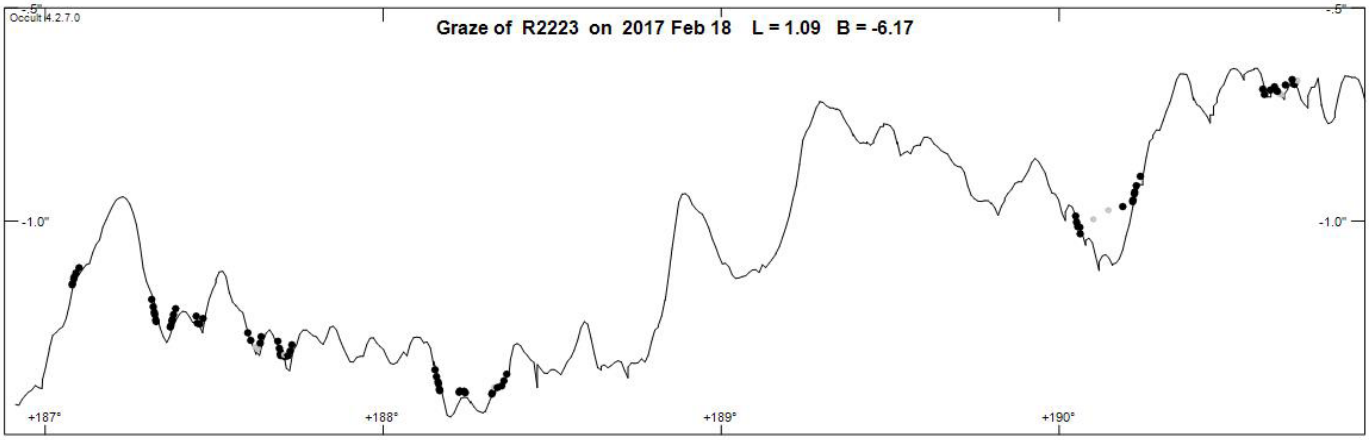
There were various teams, including Citizen's Science Centre, JVP and Akashmitra and from Pune and Nehru Planetarium from Mumbai.

Paul Maley, leading asteroid occultation observer from United States of America and ex-vice president of IOTA was also in Pune for the event. "Paul provided technical support. He brought eight video recording equipment sets and pointed accurately at a field where the star being occulted was to arrive at the time of the occultation. Based on all the observations, Paul and his team analysed and deduced the shape of the asteroid 22 Kalliope," said Deepak Joshi of JVP.

Joshi further explained why such observations are important. "Though asteroids mainly far away in the asteroid belt between Mars and Jupiter, they can sometimes wander and change their path under influence of Jupiter's gravity. Many asteroids come very close to Earth when their orbits are changed due to the pull of Jupiter's gravity. These near earth orbit can be a hazard to life here. Thus, understanding their size and orbit is very important."

Atilo Poro and Zeinab Lesani presented a new mobile application of timing via a pre-recorded video. Unfortunately the audio was not discernable form the video. They began by describing the current timing methods and their problems. The goal was to have a timing method that was accurate, standalone, eliminating the problems of manual methods, was temperature independent and freed the observer's hand for other duties and the observer could add comments instantly. The time base for the method was the GPS ABC unit made by Dave Gault from Australia. Several screenshots were shown to demonstrate how the timing method works. The method works on a computer and has options for storing start/stop times, and sending a report form with the times. Dave Gault assisted them with the development of this system.

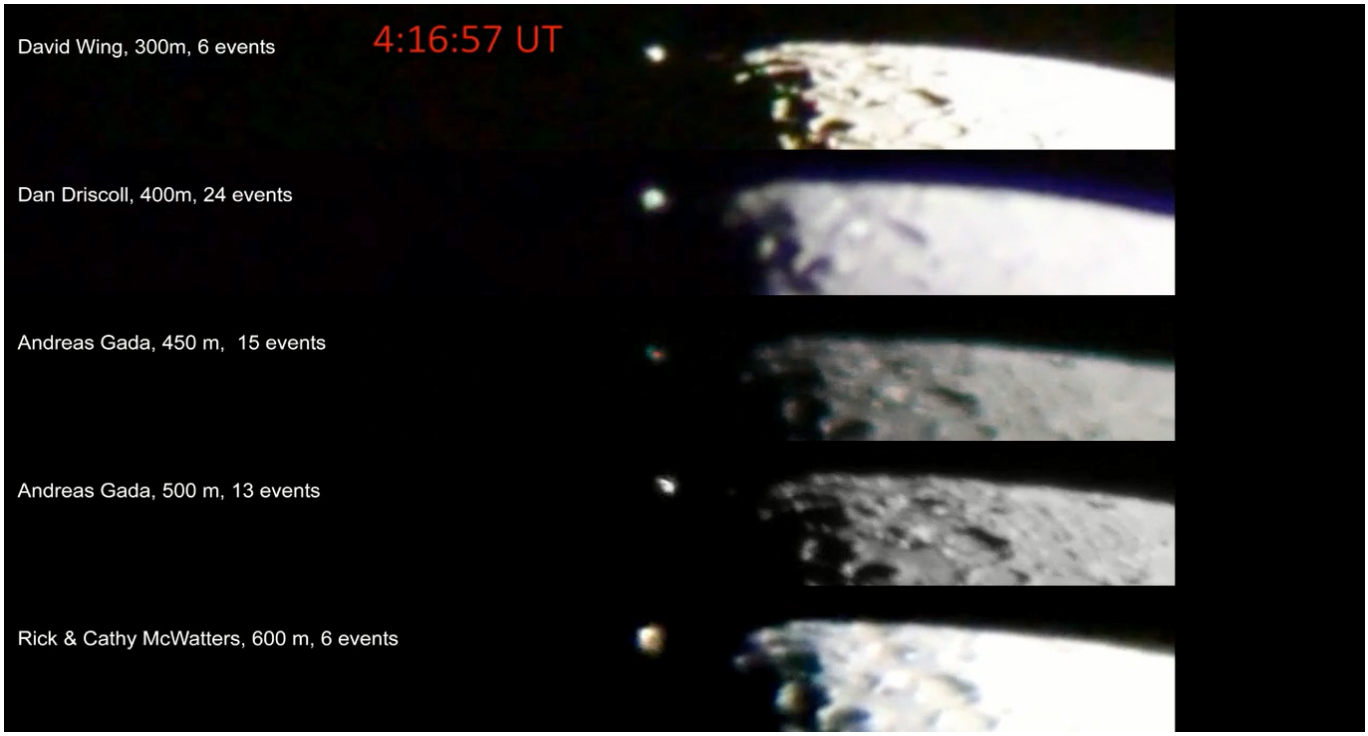
Dr. David Dunham next presented the results of two recent grazes of Aldebaran. One graze was 29 Jul 2016 during the 2016 IOTA meeting near Stillwater, OK. On 2017 Jul 29 a graze path in the USA went from El Paso, TX to the Great Lakes. For this graze David and Joan Dunham drove to Childress, TX. He set up 7 stations on sites predicted by Ernie Iverson. He showed the resultant limb profile with his observations. Next he showed the Feb 16 2017 m=+3.9 gamma Librae graze and one of the light curve recordings. This graze was chosen due to the fact that the lunar profile would offer many D and R events. The observations (4 unattended stations and 2 attended stations) matched very well with the lunar limb profile:



Observations and limb profile of Gamma Librae graze Feb 18, 2017 by Joan and David Dunham, during last quarter Moon. Vertical scale is 30X exaggerated relative to the horizontal scale.

The next Aldebaran graze was March 4, 2017 with the path going across the northern USA. This was the best graze in the current series as the next series will be in 15 years. He had successful recordings at 3 stations. Being the coldest night of the year, the other stations failed.

Another team led by Andreas Gada set up 10 stations and 5 video systems. Their spectacular combined synchronized video is here: https://vimeo.com/209854850



Dr. Roger Venable went over the 357 Ninina event from the previous night. There were 6 preliminary positives and a one unsure event from Nugent.

David Dunham next presented preliminary results from the Aug 21, 2017 total solar eclipse. This eclipse was the most recent in the series of IOTA's continuing study on measuring possible solar radius observations. One issue is that an accurate disappearance of a Baily's bead is not as easy as it looks. With LRO lunar profile data, central path timings are useful in addition to edge observations. With the widespread advertising of this eclipse, the Citizen Science Edge Determination project was started but not enough observers were interested as compared to the Jan 1925 eclipse that went over New York City. At the St. Louis Eclipse Expo on June 17, 2017, Aart Olsen had a booth to help recruit observers.

A method used in the past to estimate the moment of totality start/end is the flash spectrum technique. This technique shows the spectrum of the corona when totality starts/ends. It has been used by Japanese observers in the past with limited success. David next showed observers who made observations at the northern and southern limits and described a few of the equipment setups, some of their sky conditions and results. A few timed observations were made at the center of the path by Ernie Iverson in Nebraska, Eberhard Bredner, Chris Anderson in eastern Idaho, Carles Schnabel at Nampa, Idaho and Derek Breit in Oregon. Derek was able to get time inserted timings of 2nd contact but had cloud problems for 3rd contact. David showed 6 eclipses that occur through 2014 including an annular (Oct 14, 2016) and total eclipse (Apr 8, 2024) whose paths cross the continental USA intersecting near Austin, Texas.

Bill Hanna and **Roger Venable** then described their Aug 21, 2017 eclipse experience and equipment issues.

David Dunham next presented "Upcoming Grazing Occultations": Regulus 2017 Oct 15, Oregon to Quebec. Low altitude in Oregon, Idaho (11deg), David showed some Google maps of some of the areas.

Aldebaran, 2017 Dec 30, across central Florida, the Moon will be 93% sunlit
Aldebaran, 2018 Jul 10, 11% sunlit Moon, near twilight

David showed a page of other North America grazes from the Observer's Handbook for 2018 published by the Royal Astronomical Society of Canada.

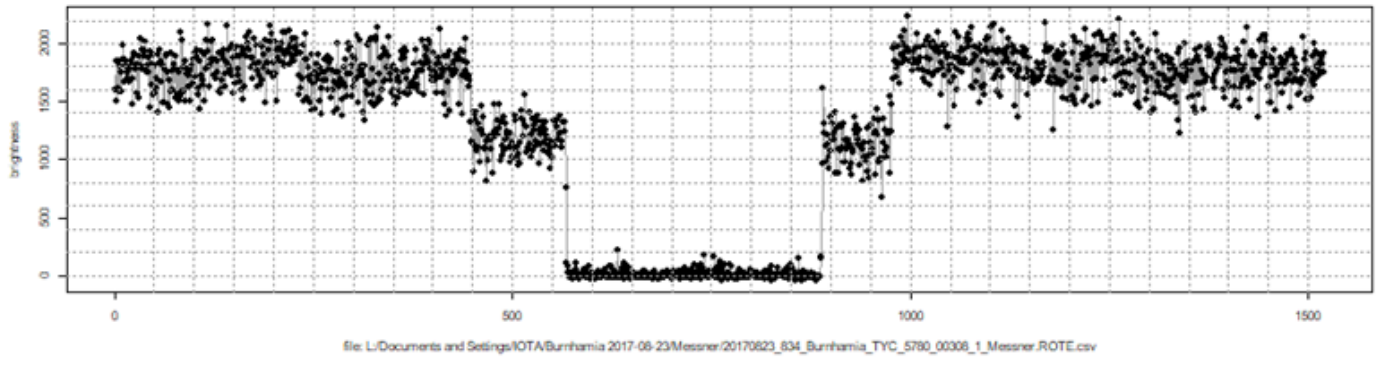
David then showed a high resolution video of the Baily's beads from the Aug 21 eclipse near one of the limits showing the mesosphere.

Steve Preston presented the best North America asteroid events remaining for 2017.

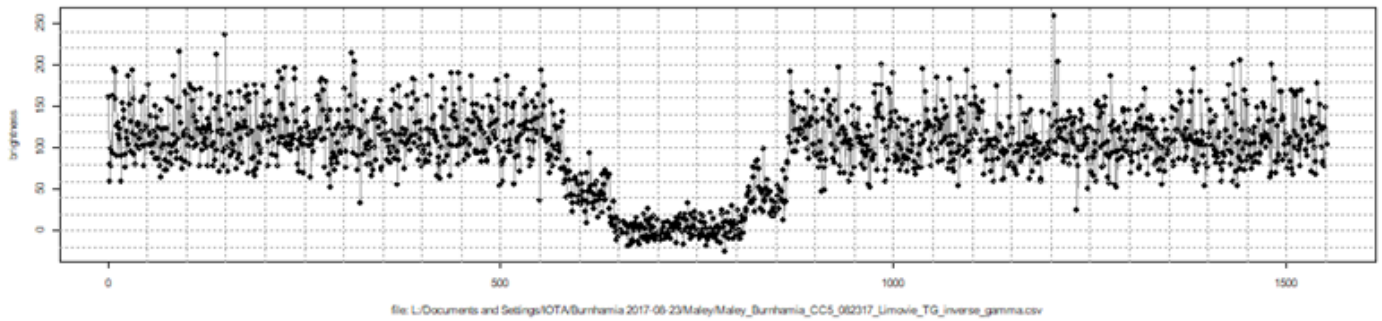
Roger Venable then went over site assignments for the 241 Germania event.

12:15 -1:35 PM – Lunch Break

Tony George presented the discovery of a double star from the occultation by 834 Burnhamia of the m = +9.2 star TYC 5780-308-1 from by observers Ted Blank, John Moore, Paul Maley and Steve Messner. The event occurred on 2017 Aug 23 and each observer had double dips in the light curves.



Messner light curve. Star was saturated, causing brightness fluctuations in the baseline and abnormal noise in the event bottom.



The separation came to 0.0143″± 0.0004 and PA = 73.8° ± 2.6°. The results will be submitted to the Journal of Double Star Observations (JDSO).

Tony then spoke about the RunCam Night Eagle Astro Edition camera. Its a low cost (under $100), high sensitivity camera for observers. Its horizontal resolution is 800 TVL lines, min lux of 0.00005 lux, small lightweight, 14.5 gm and power requirements 5-17 v. The camera also has three built in integration times, Tony has extensively analyzed the camera and had earlier in the year had uploaded his test reports. The camera has on-screen-display (OSD) for adjusting settings such as NTSC/PAL, integration times, shutter speed, image enhance, gain, mirror image, brightness and zoom. Tony has reached (with integration) stars to m = +14.2 using his 12″ SCT with no hot pixels! He then showed slides of the various settings and how to use them to maximize the quality/contrast of the videos. The RunCam camera also has a FOV just about 1 arc minute smaller than the Watec 902 camera series, as the chip size is slightly smaller than the Watec chips.

The camera had a slight problem with light leaks, and Tony showed how to fix them by opening the back of the unit (by adding a piece of foam around the boards) or sealing the edges with tape. The RunCam camera is no longer on the company website however they will sell to IOTA (through Ted Blank) in bulk orders of 10 cameras. Ted put together a package consisting of the camera, adapters and a focal reducer for $185 (meeting price $170). Persons wanting to own this camera should get with Ted Blank. Several papers on the RunCam Night Eagle's performance and features for occultation use are given below:

ArtStar test results for: RunCam Owl Plus, by Bob Anderson September 22 2016, IOTAoccultations
https://groups.yahoo.com/neo/groups/IOTAoccultations/files/Light-curve-analysis-papers/RunCamOwlPlus-report.pdf

Test report: RunCam Night Eagle Astro (prototype) by Bob Anderson, 20 April 2017
http://occultations.org/documents/RunCam-Night-Eagle-Astro-test-report.pdf

Testing RunCam Night Eagle by Tony George, December 2016, The RunCam Night Eagle CCD Video Camera is tested against three other cameras: WAT910HX, PC164C-EX2, and RunCam OWL Plus
http://www.occultations.org/documents/NightEagle-Comparison.pdf

Steve Conard next presented his talk about the QHY174M-GPS camera. Steve and Bruce Holenstein bought them when they came out earlier this year and even with limited testing, SWRI chose to use them for the MU69 event this past summer. Steve showed a comparison of the camera to the Watec 910-HX camera. The QHY has smaller pixels, larger chip size (and thus larger FOV) and outputs via USB3. Regarding cost, the QHY setup cost about $360USD more than the Watec 910-HX but it does have GPS timing built in. Steve mentioned that due to the large chip size the only focal reducer that comes close to fitting is the Antares 0.5x from ScopeStuff for $52USD.

Steve next talked about the Triton occultation on 2017 Oct 5. Details are: Star magnitude = +12.4, Triton m = +13.5, the separation from Neptune is 11.4″ with a max duration 161sec. SwRI is making an effort to observe from the centerline in northern Florida being led by Eliot Young. MIT has a very organized effort: https://hubble.mit.edu/. They currently list 8 fixed observatories in the US. Per the IOTA agreement with Bruno Sicardy, we (IOTA) are obligated to share our data with his group.
SWRI plans to have 24″ and 20″ portable telescopes on the centerline with one visible and one SWRI camera. (2) UVa C-14's with Hyperstars, 3 fixed observatories in mid-Atlantic/New England. Additionally, they will send ~6 Skywatcher 16″ telescope systems to the area around the centerline.

Dave Herald next spoke about Gaia's impact on asteroid occultations. A number to remember is that 1 mas (0.001″) uncertainty for main belt asteroids corresponds to about 2km on the Earth's surface. In the pre-Gaia era, typical star position uncertainties wewre 50 mas, and for asteroids 150 mas. Gaia's sensitivity is down to m = +20 and the detectors are saturates at m = +12, however they can measure down to m = +3, its hoped they can measure the 243 stars brighter than m = +3.

Gaia will provide the following:

- μ-arcsec (0.000001″) positions, proper motions & parallaxes down to m =+20 (~1 billion stars) – meaning distances to the center of the galaxy can be achieved to ±10%. precision
- Radial velocities and spectral types – stars down to m ≈+16 (~150 million stars), Gaia has a spectroscope
- Element abundances for stars brighter than m = +11
- Positions and orbits of asteroids and TNOs, to m =+20

For variable stars:

- 5,000,000 'classic' Cepheids
- 3,000,000 eclipsing binaries, with precise physical and orbital parameters for 10,000
- 300,000 with rotationally induced variability
- 250,000 Miras and SR variables
- 60,000 - 240,000 ″Scuti variables.
- 70,000 RR Lyrae
- 20,000 supernovae

AAVSO Index catalogue has a mere 342,000 entries

For double stars, expected results:

- 700,000 radial velocity orbits
- 800,000 radial velocity + astrometry orbits
- 2,000,000 astrometry orbits
- 4,000,000 non-linear-proper-motion systems
- 40,000,000 resolved binaries
- Resolve all binaries with separations >20mas which have a moderate magnitude difference.

The current Washington Double Star catalogue has 135,000 pairs
USNO 6th Interferometric catalogue: 83,000 pairs

Gaia data will be used to combine proper motion data from previous catalogues:

- Gaia14 – Tycho-Gaia, plus all Gaia stars to mag 14.0, with proper motions derived using UCAC4 mean epoch positions
- HSOY - Hot Stuff for One Year (Univ. of Heidelberg) - Proper motions derived from PPMXL positions
- UCAC5 – Proper motions derived from a re-reduction of UCAC images using Tycho-Gaia to derive early epoch positions

For asteroids in the May 2018 release, 100,000 asteroid positions (not orbits) are expected. Dave said that (obviously) asteroid positions are fully dependant of Gaia's spacecraft position in its orbit in the solar system. Dedicated telescopes are being used to image Gaia against the stellar background to get its accurate position.

Gaia's final release is planned for 2022. The astronomical community will enjoy a full set of astrometric, photometric, and radial-velocity catalogues. All available variable-star and non-single-star solutions will have been completed. Multiple astrophysical parameters (derived from BP/RP, RVS, and astrometry) for stars, unresolved binaries, galaxies, and quasars will be included. In addition, there will be:

- An exo-planet list.
- All epoch and transit data for all sources.
- All ground-based observations made for data-processing purposes.

With high accuracy asteroid occultation predictions, he suggested we identify and give preference to observations of binary asteroids, asteroids with shape models, asteroids having some other characteristic of importance. (eg. member of certain classes of asteroids – whether that be based on composition, orbit type, or some other consideration) and events with smaller, fainter asteroids can be predicted more often.

Dave Herald presented screen shots on how to report light curves with Occult. Dave has uploaded over 3,000 light curves to the VizieR database. Why do this? At video recording rates of 30 fps, an angular resolution of 0.01" can be obtained. Light curves contain important information of occultation reductions and having them available can assist current and future investigators, thus they should be retained. Light curves can show the presence of a double star either by discovering or confirming them. A new feature of Occult is the ability to view existing light curves, if they exist for a particular event. Occult now has the feature to get light curves from Limovie. Tangra has this capability to transfer light curves to Occult. Light curves can also be viewed in Occult. Occult will remind you in 30 days if you've not uploaded your light curves.

Light curves are available for viewing/download on VisieR under B/occ. After the talk ended, Dave answered a few questions from online attendees.

The Meeting Ended at 4:30 PM.

IOTA's Annual Meetings

Beyond Jupiter

The world of distant minor planets

Since the degradation of Pluto in 2006 by the IAU, the planet Neptune marks the end of the zone of planets. Beyond Neptune, the world of icy large and small bodies, with and without an atmosphere (called Trans Neptunian Objects or TNOs) starts. This zone between Jupiter and Neptune is also host to mysterious objects, namely the Centaurs and the Neptune Trojans. All of these groups are summarized as "distant minor planets". Occultation observers investigate these members of our solar system, without ever using a spacecraft. The sheer number of these minor planets is huge. As of September 2017, the Minor Planet Center listed 719 Centaurs and 1816 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 (KG).

In this issue:

Oliver Klös, IOTA/ES, Eppstein-Bremthal, Germany, oliverkloes@nexgo.de

Abstract

The asteroid that became a comet - this statement would describe the history of (60558) Echeclus perfectly. Discovered in 2000, the minor planet surprised observers with an outburst in 2005 and the unusual object got a comet designation. Activity could be observed in 2011 and 2016. Now on its way to the outer regions of the solar system, Echeclus is still an object of great interest. Occultations in the future may improve the knowledge about this Centaur.

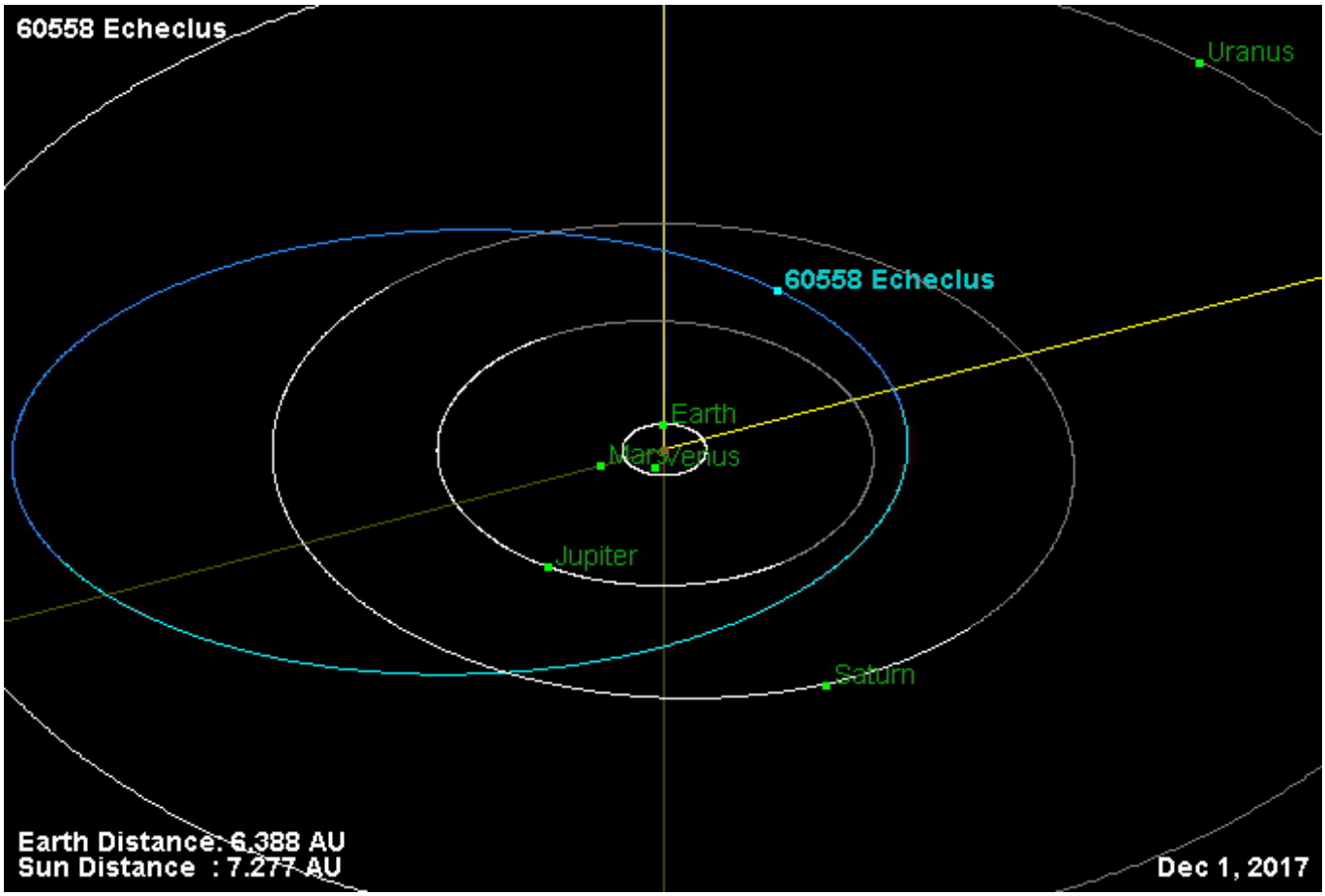


Fig. 1: The orbit of (60558) Echeclus in December 2017. The Centaur is now on its way to aphelion. Orbit diagram: JPL Small-Body Databse

Centaur

The asteroid (60558) Echeclus belongs to the class of small solar system bodies known as Centaurs, which are small objects orbiting the Sun between Jupiter and Neptune. Centaurs have very unstable orbits that crossed or will cross the orbit of one or more of the giant planets.

Discovery

This small object was discovered by Terry Bressi of *Spacewatch* on 2000 March 03. The new object received the designation 2000 EC_{98} and later (60558) Echeclus. The name derives from Greek mythology. Echeclus was a Centaur, a being half horse half man, who was killed in a battle. This was mentioned by the Greek poet, Ovid in his *"Metamorphoses 12"* [1].

Orbit and Physical Characteristics

The Centaur reaches out in the solar system as far as 15.54 AU at aphelion, so this celestial body does not cross Neptune's orbit. Moving inward the solar system it passes the orbit of Saturn to reach perihelion at 5.82 AU (Fig. 1). On its way the Centaur intersects as close as 0.83 AU the orbit of Jupiter and even closer to Saturn – 0.2 AU. The orbit has an eccentricity of 0.46, a semi-major axis of 10.68 AU and a period of 34.9 years. (60558) Echeclus came to its latest perihelion in April 2015. The diameter of 84 km of the Centaur was determined with the *Spitzer Space Telescope* in 2007 by John Stansberry et al. [2]. Another measurement comes from the *NEOWISE* survey with a diameter of 59 km only [3]. Rotation period is thought to be about 26.8 h and its rotational light-curve exhibits a maximum amplitude of 0.24 mag for the R band [4].

Surprise in the Year 2005

Choi et al. observed on 2005 December 30 with the 5.0-m telescope at Palomar, U.S.A., a cloud of dust around the Centaur accompanied by a large detached fragment. Former observations indicated Echeclus as an inactive body. Sublimation of water ice as the cause of the outburst was ruled out because at the time it was located far from the Sun at a heliocentric distance of 13 AU. So an impact of another object or the release of volatiles could be possible explanations for its activity. Bauer et al. observed the Centaur in IR and visual wavelengths in 2006. They came to the conclusion that the dust particle size distribution is more characteristic of cometary activity than being caused by an impact [5]. Because of its comet-like behaviour, the Centaur received one more designation in 2006: 174P/Echeclus

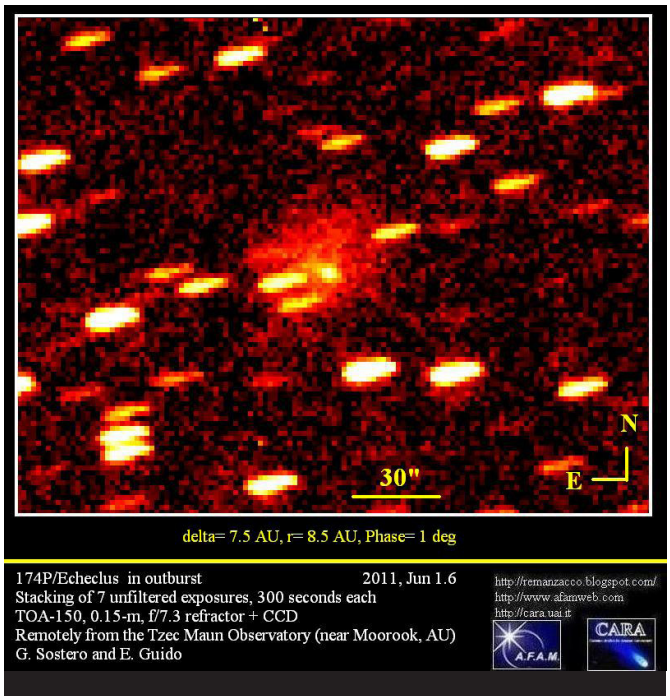


Fig. 2

2011 - Outburst!

On its way to perihelion, Echeclus exhibited an outburst at a distance of 8.5 AU.

Giovanni Sostero and Ernesto Guido made images with the 0.15 m refractor at Tzec Maun Observatory (near Moorook, Australia) (Fig. 2). They reported: *"We noticed also the presence of a jet-like feature nearly 6-arcsec long, emanating from the central condensation toward PA 60. A faint, spiral-like coma, having a total magnitude of about 16 and a diameter of 40-arcsec, surrounds the central condensation, resembling much comet 29P during the early phase of one of its recurrent outbursts."* [6].

Activity Close to Perihelion

Echeclus reached its perihelion in April 2015. Amateur astronomer Paul Camilleri observed the comet using a 0.30-m Schmidt-Cassegrain at the Blue Mountains Observatory, Leura, Australia, on 2016 August 28.69 and found it to be more than a factor of 10 brighter than when he observed it 22.5 hours earlier! Just a few hours later the outburst was confirmed with the *Las Cumbres Global Observatory* network 1.0-m telescope at Sutherland, South Africa. Camilleri had made his observation very close to the first moment of activity. Back-tracking the motion of

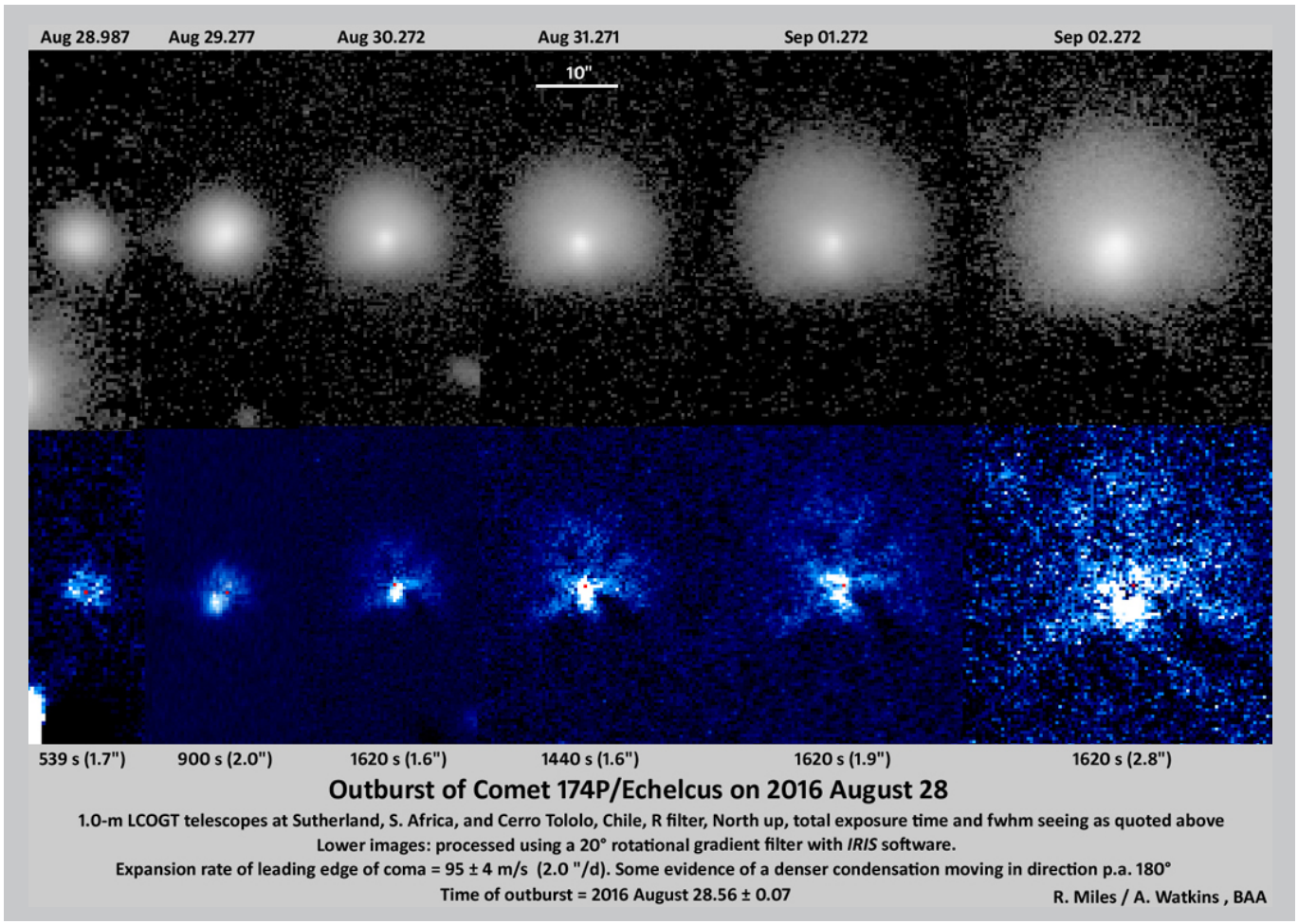


Fig. 3

the growing shell of dust on later images indicated that Camilleri had made his observation just 1-3 hours after the start of activity [7]. The activity, in the form of a gradually expanding coma, lasted a few weeks and was the last outburst witnessed to date (Fig. 3).
Wierzchos et al. measured the coma of Echeclus in May-June 2016 at 6.1 AU, i.e. prior to its latest outburst, and found its CO outgassing rate to be about 40 times lower than what is typically seen for another active Centaur, 29P/Schwassmann-Wachmann 1 at this distance. The reason for the difference is not clear but it may be because Echeclus has a much weaker crust than 29P [8].

Upcoming Occultations

On 2012 June 25, Jan Maarten Winkel (The Netherlands) has made the only observation of an occultation by Echeclus so far. A diameter of ~55 km was determined from this single chord event [9].
Echeclus is now on its way to the outer regions of the solar system again. Beside photometric observations, the measurements of occultations could help to monitor the behaviour of the strange Centaur. I used the latest Astorb data (Oct 2017) and the Gaia14 catalogue of Dave Herald's *Occult V4* to search for occultations for the years 2018-2024.

The following events were predicted (target star brighter than 13 mag):

Date (y m d)	Time (UT)	Target star	Mv (mag)	Duration (sec)	where to observe
2019 02 04	04:11	4U 529-6979	11.1	19.6	South America
2021 09 07	21:13	4U 545-32220	12.9	3.7	Asia
2021 12 05	10:57	4U 543-32057	12.7	3.7	North America
2022 01 06	08:30	4U 544-28555	9.7	3.3	Central & S. America
2022 02 02	11:27	4U 545-26432	9.2	4.5	Asia
2022 09 25	00:47	4U 542-39350	11.9	4.8	Russia, N. Europe
2023 02 16	21:24	4U 543-36682	12.9	5.0	Southern Africa

We shall have to wait for more accurate astrometry, more especially subsequent releases of Gaia data, to enable us to make better predictions in future involving many more stars than investigated here. So let's keep watching this unusual celestial body!

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[4] Rousselot, P. et al. 2005. *Photometric study of Centaur (60558) 2000 EC_{98} and trans-neptunian object (55637) 2002 UX_{25} at different phase angles,* Icarus 176, pp. 478-491

[5] Bauer, J.M. et al. 2008. *The Large-Grained Dust Coma of 174P/Echeclus,* Publications of the Astronomical Society of the Pacific, Vol. 120, No. 866, pp. 393-404

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[8] Wierzchos, K. et al. 2017. *Carbon monoxide in the distantly active Centaur (60558) 174P/Echeclus at 6 AU,* AJ, 153, 230

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Further Reading

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ESOP XXXVI

Report of the 36th European Symposium on Occultation Projects

Freiberg, Sachsen, Germany · 2017 September 15-17 (18-19) · www.esop36.de/

Alex Pratt · IOTA/ES, BAA · alex.pratt@bcs.org.uk

ABSTRACT: A total of 40 amateur and professional occultation observers and researchers from Algeria, Austria, the Czech Republic, France, Germany, the Netherlands, Poland, Ukraine, the United Kingdom, and accompanying persons, attended the 36th annual science meeting of IOTA-ES in the picturesque university town of Freiberg, Sachsen, Germany over the weekend of 2017 September 15 to 17, followed by social excursions on the next two days. Video links enabled two live online presentations from colleagues in Iran and one from the UK.

(R. Behrend)

Freiberg is known as the Silberstadt (silver city) because more than 800 years ago miners found rich seams of silver, lead, zinc and tin. Their skills developed into scientific studies of the geology of the area and Freiberg is now the home of the Bergakademie (mountain academy) Technical University, which offers degrees in subjects such as chemistry, geo-engineering and mining, geophysics and nanotechnology.

Informal proceedings commenced on the Friday evening with delegate registration at the Krügerhaus – home of an impressive display of minerals and gem stones from across Germany – and a barbecue reception in its grounds. The portable M2 50 cm f/4 telescope was set up nearby for viewing, at a safe distance from the catering. The symposium presentations took place during the Saturday and Sunday. Accompanying persons were invited to join excursions to places of interest.

On the Saturday morning ESOP XXXVI was formally opened by Dr Wolfgang Beisker. He announced that the President, Hans-Joachim Bode had passed away after suffering a stroke. Hans founded the Astronomical Working Group of Hannover (AAH) and after discussions with Dr David Dunham (IOTA) he formed IOTA-ES. The first ESOP took place in Hannover in 1981. Hans was a great promoter of the value of occultation observations and he motivated many of us to take up the challenge and present our results in the pages of JOA.

Alex Pratt gave a brief presentation about Melvyn Taylor, a UK member of IOTA-ES and a skilled observer of variable stars, meteors, comets and lunar occultations, who passed away in August. Wolfgang invited the delegates to take part in the ESOP tradition of singing "For he's a jolly good fellow…" to remember our absent friends.

The symposium continued with a most interesting and varied series of talks. The majority of the presentations, in PDF form, can be viewed here: www.esop36.de/seiten/programm.php
and the abstracts are summarised below:

Saturday Session 1

Emerging technologies
(chaired by Wolfgang Beisker, IOTA-ES)
Kryoneri – a 1.2m telescope with high-speed cameras (Dr Detlef Koschny, ESA)

Detlef Koschny gives details about a telescope for observing lunar impact flashes. (G. Dangl)

The National Observatory of Athens owns and operates the 1.2 m Kryoneri telescope in the Peloponnese. In 2015-16 it was refurbished and equipped with a camera system to observe lunar impact flashes. The project name is NELIOTA (NEO Lunar Impacts and Optical Transients). These flashes are generated when centimetre- to metre-sized meteoroids hit the lunar surface. Observing lunar impact flashes allows us to improve our knowledge of the flux density in this size regime.
The telescope was upgraded with new electronics and some mechanical parts. A field corrector with a dichroic beam splitter with a cut-off at 730nm was installed. Two cameras allow us to exclude false detections caused by cosmic rays. Due to the beam splitter, the ratio of the event brightness allows a very rough temperature estimate of the impact flash.

Airborne Occultation Observations: Past, Present and Future (Karsten Schindler, Deutsches SOFIA Institut, Universität Stuttgart, Germany; SOFIA Science Center, NASA Ames Research Center, Moffet Field, CA, USA)
Stellar occultations have been observed from airborne platforms for more than four decades. Flying above the troposphere's weather, clouds and ~75% of Earth's atmosphere, airborne telescopes allow observations at optimal locations that are almost unaffected by scintillation noise. This enables photometric measurements with very high precision. The Stratospheric Observatory for Infrared Astronomy (SOFIA) continues the occultation program begun by the Kuiper Airborne Obsservatory (KAO), and observed two Pluto occultations in 2011 and 2015 to study the evolution of Pluto's atmosphere. SOFIA's next endeavour will be the Triton occultation on 5 October 2017, aiming to intercept the centre of Triton's shadow off the coast of Florida and observe the central flash. This mission will be the first opportunity for European observers to collect data simultaneously with SOFIA, to collect essential data points at different latitudes and contribute to SOFIA's quest to analyse Triton's atmosphere.

Do It Yourself – cheap VTI based on Arduino project (W. Burzynski, IOTA-ES)
Every observer of occultation phenomena, even inexperienced in electronics and computer science, can build his own video time inserter. The Arduino programming platform allows you to do it quickly and simply – the device is constructed from ready-made components, building blocks. At the heart of the device is a simple 8-bit Atmel AVR microcontroller and its software and libraries are available on the internet as open source. For less than 100 Euro you can make yourself a reliable time-keeping device. In addition, the Arduino board can be the basis for the construction of other observation devices, such as a sky quality meter or a cloud detector.

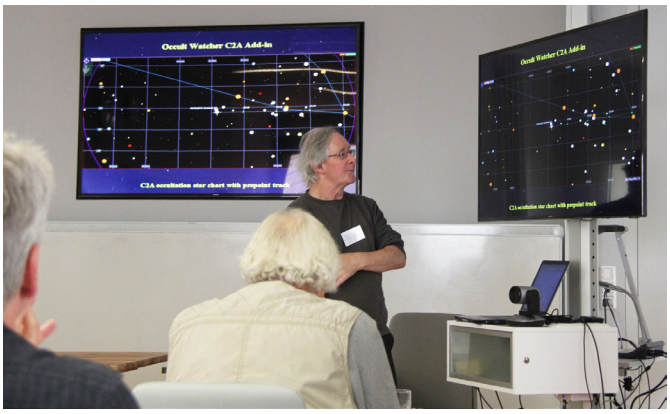
Applications of Max and Moritz (Dr Eberhard Bredner, IOTA-ES)
Organising occultation observations often means that there are participants but they don't have the appropriate equipment. So I created Max and Moritz, now also Witwe Bolte. These are completely independent electronic sets but are ready to obtain precise data – the user only has to provide a suitable telescope.

Saturday Session 2

Asteroids (chaired by Wolfgang Beisker)
Simulation of asteroid rotation
(Atila Poro, Fatemah Montazeri Najafabadi, IOTA-ME)
This was an online video presentation from Iran, illustrated by computer slides.
The physical properties of minor planets, such as rotational states and shapes, represent a portrait of both history and evolution of these small solar system objects. Building a 3-dimensional shape model is theoretically possible from 2-dimensional models; yet this has not been performed effectively with just occultation data. But many such models have been constructed from light curve inversion.
In some light curves we see two minima and the increase in brightness – we call this phenomenon 'flashing'. Observation of this effect will be easier to determine physical characteristics of asteroids. The flashing could be caused by its rapid rotation or an asteroidal ring. So in this work, by simulation, we can guess the rotational speed of an asteroid that makes it flash.

Introducing a New Mobile Application for Timing (Zeinab S. Lesani, Atila Poro, IOTA-ME)
This was an online video presentation from Iran, illustrated by computer slides.
Accurate and correct timing is very important in astronomical research, because it provides data for future studies. One of the main problems of amateur observing is accurate timing. Any minor error leads to incorrect results and the observer's attempts are not effective. Therefore, an accurate and accessible method is very important, so I tried to create a mobile 'phone application, called "SKYTIMING".
"SKYTIMING" is an accurate timing application (minimum desired accuracy is 0.01s). It's always available and standalone. The observer just needs a smart 'phone and a telescope to have an accurate timing and send a global standard report using it. It eliminates the problems of other methods.

Occult Watcher Add-ins (Alex Pratt, IOTA-ES, BAA)
Occult Watcher supports and includes a number of Add-ins, which are additional modules to help the observer. The presentation briefly introduces and discusses the Add-ins: C2A, Lunar Occultations and IOTA Reporting.



Alex Pratt demonstrates useful add-ins of Occult Watcher. (G. Dangl)

C2A is planetarium software for displaying the star field of an occultation, including pre-pointing tracks.
The Lunar Occultations Add-in lists any occultations of close double stars from the IOTA feed.
The IOTA Reporting Add-in uses a template to auto-fill the asteroidal occultation report form. This simplifies the reporting process for European observers and reduces the risk of mistakes when entering information.

New observations of asteroidal occultations in Algeria (Djounai Baba Aissa, Algiers Observatory CRAAG)
Over the past few years we created a research project to study stellar occultations by asteroids and especially Near-Earth Asteroids from Algiers' Observatory (CRAAG). We observed positive and negative events by visual methods.
Moreover, we created the first Algerian Asteroidal Occultation Network in December 2016. During this event more than thirty astronomical associations from different regions of Algeria participated in the first Algerian Training Course of Asteroidal Occultation studies. We will describe what we have accomplished. Otherwise, we will discuss the work we have done during July and August 2017.
We carried out an observation campaign to study several low probability asteroidal occultations using IBEROC and IOTA data. We employed the 80 cm Ritchey-Chretien reflector coupled with a Watec 910 video camera and IOTA VTI GPS inserter. We will present the principal results that we obtained.

Eclipses and occultations of (22) Kalliope and the moon Linus (Bernd Gaehrken, Public Obssevatory, Munich)
Many asteroids have moons but most of them are small and deliver no significant drop during an eclipse or occultation. With Kalliope and Linus the ratio between the diameters is 1:6. In regards to the surface area it is 1:36. So a drop of 0.03 magnitudes is expected… But the shape of Kalliope is not a ball, it's a pancake. The geometry also allows drops of greater magnitude. The talk shows some measurements made during the winter of 2016/17.

Saturday Session 3

Lunar occultations I and previews (chaired by Christoph Bittner)

Gerhard Dangl shows a map with the graze line. (O. Klös)

Grazing occultation of Aldebaran by the Moon in the daytime sky (Gerhard Dangl, IOTA-ES)
Following the lunar occultation of the bright star Aldebaran (alpha Tauri) in 1999, it is occulted several time during 2015 to 2018, then it will not be occulted again until 2034. In addition to total occultations, there are several grazing occultations in 2015-2018.
For a site in Austria, five grazing occultations were listed for 2016-2017. Before midday on 8 May 2016 a grazing occultation of Aldebaran was observed at the Moon's north pole. The location was selected using a self-designed Excel spreadsheet. The daytime observation was difficult. Since Aldebaran is a K5 type star, an infrared filter was used in the blue daytime sky.
Six events were recorded, but because of poor contrast and strong winds, automated video analysis software couldn't be used. The speaker manually analysed 10,000 video images. The measurements were sent to the IOTA graze coordinator in Japan.
http://www.dangl.at/2016/moon/moon_aldebaran_20160508_e.htm

Eberhard Bredner reports about grazing occultations. (D. Dangl)

Reports about recent grazing occultations (Eberhard Bredner, IOTA-ES)
IOTA-ES has the powerful software GRAZPREP – created by Dr Eberhard Riedel – to calculate grazing occultations. So an interested observer can 'calculate' observations with high reliability regarding his opportunities / possibilities. The actual situation will be explained by some experiences.

A total lunar occultation with multiple contacts (Dietmar Büttner, IOTA-ES)
While observing a total occultation of ZC 3320 at his home location in Chemnitz on 2013 November 11 the author noticed three contacts instead of the expected single disappearance. All three contacts occurred within a timespan of only one second. The observing site was 18 km inside the predicted northern limit line for the grazing occultation of the star.
In his talk the author describes his investigations of the things that happened, concluding that this very special event was caused by an extraordinary limb profile geometry.

Profiles and Moons – Highlights of Asteroidal Occultations in Europe 2018 (Oliver Klös, IOTA-ES)
Besides providing high precision positional data of an asteroid, the main task of occultation observers is the determination of asteroids' shapes by measuring their profiles. Observing occultations by moons of as-

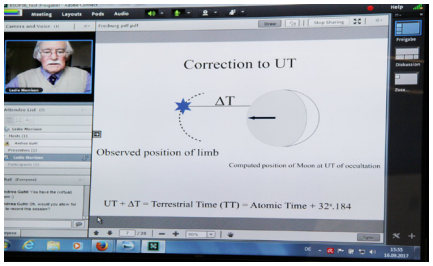
Oliver Klös presents highlights of asteroidal occultations in 2018. (G. Dangl)

teroids is possible since high frame rate video cameras are now in common use. These measurements will improve the orbits of these companions and will give precise diameters.

In May 2017, Steve Preston (IOTA) provided his first asteroidal predictions for 2018. European observers will have the opportunity to measure the same asteroid twice, which may give different profiles to improve the 3D shape models. The chase for the small moons will continue; the shadows of (216) Kleopatra and its satellites will return to Europe several times. This presentation with path maps gives a first look at some of next year's highlights.

Saturday Session 4

Lunar occultations II (chaired by Oliver Klös)
Lunar Occultations and the Earth's Rotation
(Dr Leslie Morrison, Pevensey, East Sussex, UK)



Leslie Morrison joins ESOP via the web and gives a lecture about lunar occultations and the Earth rotation. (G. Dangl)

This was an online video presentation from the UK.

Many thousands of timings of lunar occultations since AD 1623 provide the most accurate data on variations in the Earth's rate of rotation until the introduction of the atomic timescale around 1962. Analyses of these timings reveal fluctuations in the length of the day of several milliseconds on a timescale of decades. These are largely due to core-mantle coupling which redistributes angular momentum within the Earth.

Graze of 81 Tau – using GRAZPREP (Tim Haymes, IOTA-ES)

GRAZPREP 4.03 was used to predict 14 graze contacts for 81 Tauri during a recent Hyades passage. The presentation describes site selection and recording of 13 contacts, one was non-instantaneous. A further contact (RB) was on the bright limb. There was good agreement with Occult4 preliminary analysis. Initial planning was done with Occult4, and GRAZPREP was used for predicting contacts in optimised locations. The video recording can be seen on YouTube. I have two recordings from mobile stations.

https:/www.youtube.com/watch?v=SsZkFPbXZIc&feature=youtu.be [81 Tau 2017]

https:/www.youtube.com/watch?v=MvTK6rHkX7A&feature=youtu.be [Lunar Eclipse 2015]

GRAZPREP – features and limitations
(Dr Eberhard Riedel, IOTA-ES)

GRAZPREP is a freeware tool that supplies all details of grazing occultation predictions and assists in preparing successful observations as well as evaluating and reporting timings of these events. In an example of a recent observation report the possibilities as well as the present limitations of the achievable precision regarding stellar position and project lunar limb details are explained.

Saturday Evening Session

Public lectures Audimax lecture theatre
Cosmic catastrophes – consequences and likelihood
(chaired by Wolfgang Beisker)

Following an introduction by Wolfgang Beisker in German and English, these lectures were conducted in German.

Minor planet impact – geological consequences (Dr Jan Michael Lange, Bergakademie, Freiberg)
Collision with a minor planet – likelihood and countermeasures (Dr Detlef Koschny, ESA)
Round table discussion (Beisker, Lange, Koschny)

Social Dinner – Restaurant Freyhof

Sunday Session 1

Gaia and occultation astronomy
(chaired by Wolfgang Beisker)
The Gaia Mission – Status and Prospects
(Prof Stephan Jordan, Astronomisches Recheninstitut, Heidelberg, Germany)

The astrometric satellite Gaia was launched in 2013. After a comprehensive commissioning phase Gaia began its nominal scientific measurements in mid-2014. Gaia's main goal is the determination of precise astrometric data for more than one billion stars in our Milky Way with extremely high precision.

Gaia Data Release 1 was published in September 2016. It contains positions and magnitudes for about 1.1 billion stars. For two million stars proper motions and parallaxes could also be determined. More than 160 scientific papers based on this catalogue were published up to July 2017. Gaia Data Release 2 will be available in April 2018 and will probably contain more than one billion stars with positions, proper motions and parallaxes, many having a precision of better than 0.1 milliarcsecond. Positions of more than 10,000 asteroids are also expected in Gaia DR2. In order to provide accurate positions for occultations, astrometric data for several stars were published before the main data releases.

Wolfgang Beisker commemorates Hans-Joachim Bode, the former president of IOTA/ES, who passed away in July 2017. (G. Dangl.)

Wolfgang Beisker announced that the IOTA-ES committee had agreed to a proposal to remember and honour our late founder and President, so it was his proud duty to ask Bruno Sicardy to give the first annual 'Hans-Joachim Bode Lecture'.

Exploring the Solar System using stellar occultations (Prof Bruno Sicardy, Université Pierre et Marie Curie & Observatoire de Paris)

The spatial resolution obtained during stellar occultations is basically limited by Fresnel diffraction scale, i.e. typically of the order of km for objects beyond Neptune. Moreover, those events also permit the detection and monitoring of tenuous atmospheres at nbar level and led to the discovery of rings around small bodies.

The main limitation so far is prediction accuracy, typically 40 mas, corresponding to about 1,000 km projected onto Earth. This leads to much time dedicated to astrometry, tedious logistical issues, and more often than not, a miss of the event.

The Gaia catalogue, with sub-mas accuracy, hugely improves both the star positions and ephemerides of the bodies, resulting in accuracies of ~10 km for the shadow track on the Earth. Thus campaigns will be much more carefully planned, with success rates approaching 100%, weather permitting.

Scientific perspectives and recent results will be presented, e.g. central flashes caused by Pluto's atmosphere may reveal hazes and winds near its surface, grazing occultations will show topographical features on remote bodies, allowing geological studies, occultations by Chariklo's rings will unveil dynamical features such as resonances with nearby satellites or proper mode "breathing".

Sunday Session 2

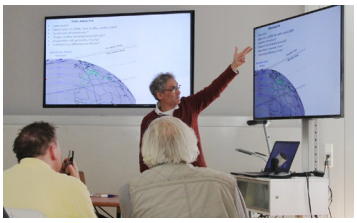
Recent and future occultations (chaired by Alex Pratt)
The occultation by Pluto on 19th July, 2016 (Wolfgang Beisker, IOTA-ES)

The 14th mag star UCAC4 345-180315 was occulted by Pluto on the evening of 19th July, 2016. The event could be observed from large parts of Europe, the Middle East and northern Africa as well. A campaign had been organised with many observers and observatories throughout Europe and other countries. The scientific goal was the ongoing monitoring of Pluto's atmosphere as well as the improvement of Pluto's astrometry. Because of the increasing distance of Pluto from the Sun, scientists are waiting for a possible shrinking of its atmospheric pressure. The astrometric positions were largely done by the RIO team and Bruno Sicardy's team. A fainter star was occulted by Pluto 5 days before (14th July). This was successfully observed and used as a "pathfinder" for the main occultation on the 19th. In a very helpful decision, the Gaia team released the star position of the target star 2 months before the Gaia DR1 catalogue was released. Together with a new ephemeris from the New Horizons team the occultation track for the 19th could be determined with very high precision (pre- versus post-occultation calculation only differed by less than 100 km).

Because of good weather conditions for the event in large parts of Europe, observations from about 30 stations could be recorded and analysed.

The Chariklo Occultation Campaign (Mike Kretlow, IOTA-ES)

(10199) Chariklo is currently the largest known Centaur. It is the first asteroid-sized object (diameter about 260 km) with a known ring system, which was discovered during a stellar occultation in 2013. For this year, three favourable occultations by Chariklo of stars brighter than ~15 mag were predicted: on April 9 and June 22 (both crossing over southern Africa: Namibia, Botswana and South Africa), and on July 23 (crossing over South America: Brazil, Paraguay, Argentina and Chile). All three events were successfully observed by international (pro-am) teams, organised and supported by the Paris / Meudon Observatory within the ERC Lucky Star project. The author (who joined all three expeditions) gives us overview about these occultations, the main objectives of this observing campaign and presents first results.



Bruno Sicardy shows the latest path prediction for the Triton event. (G. Dangl)

Triton – Monitoring changes in its atmosphere (Prof Bruno Sicardy, Université Pierre et Marie Curie & Observatoire de Paris)

On October 5th/6th the satellite of Neptune, Triton, will occult a 12m4 star UCAC4 410-143659. The occultation track passes over parts of the USA and central Europe. This event is the first opportunity since 2008 to monitor the status of Triton's thin atmosphere, which consists mainly of Nitrogen, as for Pluto. In this report a preview is given of the event, its scientific rationale as well as the observational conditions and techniques necessary to record the event.

Sunday Session 3

Beside the lectures, discussions are going on. Martin Fiedler (center) demonstrates the control software of the QHY 174 GPS. Piotr Badowski, Reiner Hopfer, Tim Haymes and Vaclav Priban are very interested (from left to right). (G. Dangl)

Practical Workshop (chaired by Sven Anderson)
Practical workshop on EXTA (Gerhard Dangl, IOTA-ES)

During this session Gerhard demonstrated his EXTA high-precision timing device and it was used to examine two video cameras brought along by ESOP delegates.

Sunday Session 4

Various contributions (chaired by Wolfgang Beisker)
The solar eclipse of 21st August 2017 (Konrad Guhl, Andreas Tegtmeier, Eberhard Bredner, IOTA-ES)

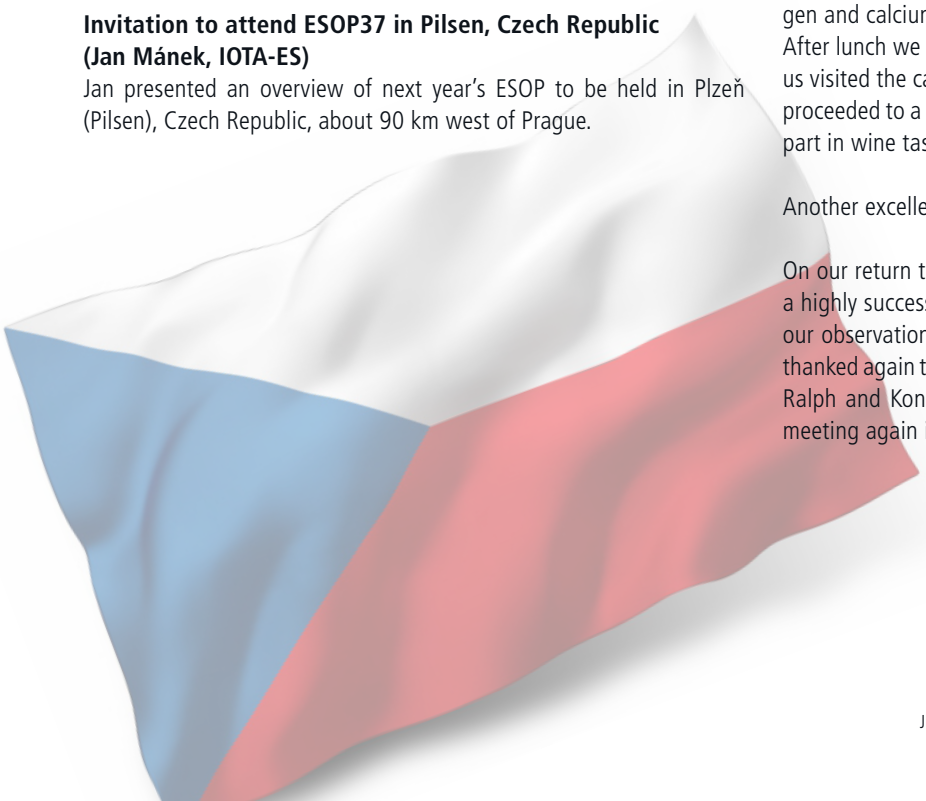
Observations of Baily's beads at total and annular eclipses have been one of the main activities of IOTA and IOTA-ES for many years. The standard observations are done at the northern and southern edge of the path of totality. For the total eclipse of August 21st 2017, these stations were manned by Elke + Konrad Guhl (north) and Carmen + Andreas Tegtmeier (south). Due to the possibility of high-speed observation and the more detailed knowledge of the lunar limb by spacecraft,

observation on the centreline appeared viable. So this eclipse became the first where IOTA-ES attempted such an observation. The station was manned by Dr Eberhard Bredner. Due to the limited time between the eclipse and the symposium, no calculation based on the video tapes is ready yet. Observers will present the raw video tapes and report about obstacles and success.
(At the end of his talk Eberhard walked out of the room and returned carrying a tray of small wine glasses. He had purchased some bottles of wine from a vineyard in the United States and offered a celebratory drink to every participant at ESOP!)

Eberhard Bredner is sharing his solar eclipse wine with the participants. (W. Beisker)

Observations of occultations by planets in the 19th century (Konrad Guhl, Archenhold Sternwarte, IOTA-ES)
The main planets of our solar system have been popular objects of observation for as long as telescopes have been in use. As a result, the study of planetary bodies led to the discovery of stars – often by accident, as new satellites the main target. These stars were then monitored – to discern them from satellites – and as events progressed, occultations were observed. Soon, the possibilities of atmospheres were discussed. During the second half of the 19th century, scientists started calculating the probability of occultations and also generated the first ephemerides. All in all, 14 different occultation events were recorded in the two leading astronomical journals, the "Astronomische Nachrichten" (AN) and the Monthly Notices of the Royal Astronomical Society (MNRAS). Notable examples will be presented and discussed.

Invitation to attend ESOP37 in Pilsen, Czech Republic (Jan Mánek, IOTA-ES)
Jan presented an overview of next year's ESOP to be held in Plzeň (Pilsen), Czech Republic, about 90 km west of Prague.



Closing Remarks

At the formal closing of proceedings the delegates expressed their grateful thanks to the Local Organising Committee of Andrea Guhl, Ralph Behrend and Konrad Guhl for a most productive and highly enjoyable ESOP.
This was followed by an extraordinary business meeting of IOTA-ES.

Monday Social Trip

Delegates and accompanying persons had a pleasant morning walk through the quiet streets of Freiberg and up the nearby hill to the site of the University research and teaching mine. After looking at the collection of mine locomotives and wagons outside the buildings, we went inside and donned overalls, rubber boots and protective headgear to be taken to the lower levels in small groups via the lift cage. One of the students was our guide through the tunnels and he explained the research work that is conducted there by the staff.
After lunch in Freiberg we had a guided tour of the town centre, including a visit to St Marien cathedral and attended an organ recital, and viewed the illustrated plaque inlaid into the paving in Schlossplatz that commemorates the discoveries of the periodic elements germanium and indium by chemists at the Bergakademie.

Tuesday Social Trip

The final day began with an excursion by coach to Radebeul observatory and planetarium, about 50 km from Freiberg. After viewing the exhibition area in the foyer, including historical telescopes, a Foucault pendulum, meteorites and Moon rock, we were treated to a high-quality night sky show by their Zeiss projector in the planetarium. A look around the shop, then over to the other buildings to view the telescopes on site. These included a 15cm f/15 Zeiss Coudé refractor, a 35.6cm f/4.5 Maksutov-Newtonian reflector, a most impressive portable 60 cm f/3.3 Dobsonian telescope, a spectrohelioscope of 3.4 m focal length, a 3 m radio telescope dish and solar telescopes for viewing the Sun in hydrogen and calcium wavelengths.
After lunch we travelled to Meissen for some sightseeing. A number of us visited the cathedral on its imposing setting over the town. We then proceeded to a family business wine producer in nearby Diesbar, to take part in wine tasting in their cellars.

Another excellent ESOP!

On our return to Freiberg everyone agreed that ESOP XXXVI had been a highly successful symposium with a full social programme to discuss our observational plans and techniques. As we said our goodbyes, we thanked again the members of the Local Organising Committee, Andrea, Ralph and Konrad for their hard work and we all looked forward to meeting again in 2018 in Pilsen, Czech Republic.

Journal for Occultation Astronomy

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.

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Impressum

Editorial board: Wolfgang Beisker, Michael Busse, Alexander Pratt
Responsible in Terms of the German Press Law (V.i.S.d.P.): Konrad Guhl

Publisher: IOTA/ES, Am Brombeerhag 13, D-30459 Hannover Germany, email: joa@iota-es.de

Layout Artist: Michael Busse, mb-grafik-design@online.de, mbusse@iota-es.de
Webmaster: Wolfgang Beisker, wbeisker@iota-es.de

Membership fee IOTA/ES: 20,– Euro a year (incl. JOA: free of charge)

Publication dates: 4 times a year

Submission Deadline for JOA 2018-1: December 15

(IOTA maintains the following web site for your information and rapid notification of events.)

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

This site contains information about the organization known as IOTA and provides information about joining

IOTA and IOTA/ES, including topics related to the Journal of Occulation Astronomy (JOA), and also has an on-line archive of all issues of Occultation Newsletter, IOTA's predecessor to JOA. On the right side of the main page of this site are included links to IOTA's major technical sites, as well as to the major IOTA sections, including those in Europe, Asia, Australia/New Zealand, and South America. The technical sites include definitions and information about observing and reporting, and results of, lunar, planetary, and asteroidal occultations, and of eclipses and other timely phenomena, including outer planet satellite mutual events and lunar meteor impact flashes.

Journal for Occultation Astronomy
(ISSN 0737-6766) is published quarterly in the USA by the International Occultation Timing Association, Inc. (IOTA)
4933 Champlain Place, Edmond OK 73025

IOTA is a tax-exempt organization under sections 501(c)(3) and 509(a)(2) of the Internal Revenue Code USA, and is incorporated in the state of Texas. Printed Circulation: 200

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