Journal for Occultation Astronomy

2016-04

Iridescent clouds

during the annular eclipse 2016 Sept. 1

IN THIS ISSUE:

Dear reader,

2016 was a year of many highlights in occultation astronomy. The GAIA catalogue appeared with its first release. Our 20 inch portable occultation telescope "**M2**" served its first scientific observation. Once more an occultation by Pluto and Chariklo with its rings could be observed to mention only the most remarkable events.

But now in 2017 the story will continue. Everybody is encouraged to record lightcurves of asteroidal occultations in order to improve the mapping of their three-dimensional shapes. The observation of mutual events of asteroids and their satellite(s) gives unprecedented insights, as for Kalliope in the first months of 2017.

Occultations by Triton as visible from Europe and by Pluto in other parts of the world will again provide fantastic opportunities to check out changes in the atmosphere of these bodies. We will also have more opportunities to view the rings of Chariklo. The observation of occultations by TNOs, as difficult as they are because of insufficient TNO-astrometry, will yield scientific results in cooperation with our partners worldwide.

Also total and grazing lunar occultations still have their scientific value and remain an important part of our observation program.

After all the extremely valuable basic work of observing occultations by main belt objects should not be neglected. With the improved position accuracy of the GAIA catalogue even for fainter stars reliable occultation tracks can be predicted for a lot more events. Using our new **M2**, interested members are enabled and encouraged to observe occultations of stars fainter than mag. 15 easily.

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In this issue:

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Gordon Taylor
An astronomical autobiography

After World War 2 I was demobbed from the RAF (Royal Air Force) but remained as a civilian meteorologist until I managed to get transferred to the Nautical Almanac Office (NAO), working in the Occultation Section. The office was in Bath but was transferred to Herstmonceux Castle shortly afterwards, late in 1949. A few years later the NAO was absorbed into the Royal Greenwich Observatory (RGO). My rank was a Scientific Assistant. (One cannot get any lower!). With several others in the Occultation Section I was using the Occultation Machine to help predict the times of lunar occultations of stars visible from the positions of observatories indicated on a globe of the Earth. It was also possible to get predictions to a number of keen amateur observers. These observations were used to determine deltaT (Ephemeris Time minus Universal Time) caused by fluctuations in the rate of rotation of the Earth. Some years later positions of radio observatories were added to the globe and this led to new discoveries being made, e.g. the first pulsar.

Observations of Lunar occultations of stars were received and used to improve the accuracy of the longitude of the Moon. By 1962 this made me wonder if we could also use occultations to improve our knowledge of the lunar latitude. I was having a bath one evening at home when I suddenly thought of a way of doing so. No, I did not follow the example of a great Greek philosopher and shout, unclothed, "EUREKA" – common sense, it does not get that warm here. I worked on the method at home, which was to predict grazing lunar occultations and then use the data from the observations. Then I presented it to the boss of the NAO (Dr Sadler). A new recruit to the computing section, J V Carey, was given the job of adapting the method for a computer program on our ICL 1909. He did a great job and we used this method for the next 20 years, getting far more observations from amateur observers from all over the world. This helped to ease me off the bottom of the ladder.

Also by 1950 I was thinking that lunar occultations of the larger minor planets (Ceres, Pallas, Juno and Vesta) might be useful. Predictions were issued starting in 1955, with little success.

At almost the same time (1952) I noticed that orbits of minor planets were increasing in accuracy, so I decided to write software programs and issue predictions of them. This led to the first one being observed on 19th February 1958 by Per-Ake Bjorklund and Svend Aage Muller of Malco, Sweden, giving a duration of 7.2 seconds at about 21h 54m UT, indicating that Juno should have a diameter not less than about 110km.

Shortly afterwards more senior members were asked if they would like to undertake calculations of occultations of stars by planets. None wanted to take on the job, so I asked if I could have a go. I was lucky. It was not very long before I had written a program and was able to issue a prediction that Venus would occult the bright star Regulus on 7 July 1959, and I published its track across the surface of the Earth.

My wife, Violet, was also working at the RGO, and happened to see the following item in Time magazine (USA) of July 1959 (Section on Science)

"Tough Calculations. The experts might have missed the event altogether had it not been for British Astronomer Gordon E Taylor, a former amateur without University training, now employed at the Royal Greenwich Observatory. At first some of the pros doubted Taylor's calculations, which were published in January; the paths of two such remote bodies are very tough to calculate accurately. Only when the august Harvard College Observatory confirmed Taylor's calculations did the occultation of Regulus became a serious concern."

It is only fair to point out that my colleagues said I would be thrown into the moat surrounding Herstmonceux Castle if it did not happen. I remained dry! Another step up the ladder!

After this it was then a routine matter to issue predictions for other planets. Mercury was attempted once but failed. In 1968 Neptune occulted a star and the timed observations led to an improved diameter of the planet. In 1971 the same happened to Io (Jupiter I), in 1972 to Ganymede (Jupiter III) and in 1974 to Rhea (Saturn V).

However, in 1973 I had calculated that Uranus would occult the star SAO 158687, spectrum K5, magnitude +8.8, thus its visual magnitude was about +10. The date was 10 March 1977. The Moon, age 21 days, would be about 17 degrees from Uranus, having occulted it on the previous day. It should be possible to refine the positions of the 2 bodies on Jan 22, 1977 as Uranus would then pass only 0.8 degrees south of the same star. The observatories at Perth and the Cape of Good Hope would be best placed for observations. The star would not be occulted by either Ariel, Umbriel, Titania or Oberon. In the USA it had been decided to send the Kuiper Airborne Observatory (KAO) carrying equipment and observers to Australia before the event started. Photographs were made from 3 observatories and results from two of them indicated that the occultation would not occur! I received a letter from Brian Marsden in the USA which said "American astronomers are running around like chickens with their heads cut off, and we have already spent $ 200,000 on our expeditions!" In the end, of course, the rings of Uranus were discovered!

In 1975 I predicted that Mars would occult the third magnitude star epsilon Geminorum on April 8, 1976. I was using the FK4 position and proper motion of the star and a recently-computed ephemeris of Mars kindly supplied by the Jet Propulsion Laboratory. The adopted radius of Mars was 3394 km.

The track would cross the western half of North America and aroused the interest of astronomers who intended to use the Kuiper Airborne Observatory near the East coast of North America. There was a very good reason for this. The impending Mars landing by a Viking spacecraft was scheduled for 4 July 1976. A successful observation of the predicted occultation beforehand would give valuable information about the temperature and composition of the atmosphere of Mars before the landing. As I was in the IAU and chairman of the Working Group for Stellar Occultations by Planets and Asteroids, I was brought in to calculate the position and timing of the KAO assuming that the height of track was at 41,000 feet, when it would be above 82 % of the Earth's atmosphere. It was also necessary for the centre of Mars to occult the centre of the star. Fortunately I got it right!

I was also requested to provide predictions of occultations of stars by comets and I did so for Comet Crommelin in 1984 and for Comet Halley in 1985.

ASTEROIDS

As ephemerides of asteroids were improving I was kept busy as chairman of the Working Group on Predictions of Occultations by Satellites and Minor Planets (IAU Commission 20)

In 1983 I was invited to speak at Uppsala University in Sweden about occultations by minor planets, how they were predicted and what were the results. I gave the following talk:

PREDICTIONS

Osculating elements of 184 minor planets, produced by the Institute of Theoretical Astronomy in Leningrad are used at the Royal Greenwich Observatory to provide daily ephemerides. These ephemerides are then searched against a star catalogue containing the position of all SAO and AGK3 stars within 45 degrees of the ecliptic. All appulses of minor planets to stars are noted and a list of possible occultations is produced and printed in various publications. Detailed preliminary predictions are issued to many observatories. Now I was able to use the Astrographic telescope at Herstmonceux to see if it was necessary to issue a revision to the original prediction. Final predictions are then issued by telex, telegram or telephone.

RESULTS

From 1953 until around 1975 predictions of occultations by Ceres, Pallas, Juno and Vesta, only, were issued. An occultation by Juno was observed visually from place and an occultation by Pallas observed photoelectrically from one observatory in India. Thus only minimum values were obtained. A short duration occultation by Eros was also observed in 1975.

OBSERVATIONS OBSERVED 1975-1981

Date	Minor Planet
1975 Jan 23	Eros
1977 Mar 5	Hebe
1978 May 29	Pallas
1978 Jun 7	Herculina
1978 Dec 11	Melpomene
1979 Aug 17	Nemausa
1979 Oct 17	Cybele
1979 Dec 11	Metis
1979 Dec 11	Juno
1980 Sep 14	Diana
1980 Oct 10	Kleopatra
1980 Nov 24	Sophrosyne
1981 Aug 7	Melpomene
1981 Oct 5	Artemis

FUTURE POSSIBILITIES

Predictions for 1982 were issued in October 1980 and those for 1983 will be available shortly. In addition predictions for Ceres, Pallas, Hygiea and Vesta have been published up to 1989.

A fourth-magnitude star, 1 Vulpeculae, will be occulted by Pallas on 29 May 1983. The predicted track crosses the Southern States of the USA, from east to west. The event will be easily observable, the magnitude change at the occultation being 4.9 visually and 5.9 photoelectrically. The maximum duration will be 46 seconds.

European astronomers should plan ahead to observe occultations by two of the minor planets in 1998, one by Vesta on March 1 and the second by Hygiea on March 8. The predicted track of the central line of the occultation by Vesta, which has a magnitude change of 0.3 visually and 0.2 photoelectrically, and a maximum duration of about 2.4 m is from northern Libya across north east Algeria, the Franco-Spanish border and then just south-west of the British Isles to Iceland. The track of the Hygiea event, magnitude changes 0.5 visually and 0.7 photoelectrically and a maximum duration of 0.6 m is from Saudia Arabia through Egypt, northern Libya and Algeria, and Iberia to Labrador.

Gordon Taylor

Gordon has been the recipient of a number of awards from astronomical associations.
The David E. Laird Award of IOTA:
http://www.asteroidoccultations.com/observations/Awards/Taylor.htm

The BAA's Merlin Medal and Gift, in 1962 and in 1979:
https://britastro.org/about-awards

An 'outstanding contribution' award, in 2009, from the BAA:
http://britastro.org/computing/history.html

ESOP XXXV

Report of the 35th European Symposium on Occultation Projects, University of Guildford Surrey, England, 2016 August 19-21 (22-23)

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

A total of 38 occultation enthusiasts from the Czech Republic, Germany, the Netherlands, Poland and Spain, including 18 from the United Kingdom, and accompanying persons, attended the 35th annual science meeting of IOTA-ES at the University of Guildford over the weekend of 2016 August 19 to 21, followed by social excursions on August 22 and 23.

Informal proceedings commenced with a buffet reception on the Friday evening and a visit to the observatory of the astrophysics department, housing a 406mm Optimised Dall-Kirkham telescope. The symposium presentations took place during the Saturday and Sunday. Accompanying persons were invited to join excursions to places of interest, such as Hampton Court, the Palace of King Henry VIII.

On the Saturday morning ESOP XXXV was formally opened by Tim Haymes and Dr Richard Miles of the local organising committee, and Dr Wolfgang Beisker on behalf of IOTA-ES. It was announced that in recent weeks the European occultation community had sadly lost regular contributors Alfons Gabel and Otto Farago. Tributes to their contributions to occultation astronomy were presented by Dr Eberhard Bredner and Andreas Eberle, and they invited the delegates to join them in remembering our absent friends.

The symposium continued with a most interesting and varied series of talks. Most of the presentations, in PDF form, can be viewed here: European Symposium on Occultation Projects XXXV | British Astronomical Association

and the abstracts are given below:

Saturday session 1
Occultations and the BAA – past, present and future (chaired by Oliver Klös, IOTA-ES)

Gordon Taylor – an astronomical autobiography (read by Tim Haymes, BAA, IOTA-ES)

Gordon Taylor sends his very best wishes to ESOP XXXV, but is unable to attend in person.

This presentation is a small part of his autobiography, written for this symposium, describing some of the many innovations he introduced into the prediction of lunar, asteroid and planetary occultations. This autobiographical account is supplemented by images from the presenter.

(See separate article – Gordon Taylor an astronomical autobiography)

UK occultation successes 1989-2015 (Richard Miles, BAA / Tim Haymes, BAA, IOTA-ES)

A summary is presented of the 1989 July 3 occultation by Titan of the star 28 Sgr, which was exceptionally well recorded by UK and European observers. An account of the first positive asteroid occultation success in the UK will also be given (Richard Miles).

More recent occultation results observed from the UK are described, the most successful of which have been those of (130) Elektra in 2010 and (275) Sapientia in 2015. A relatively large observer base in England assisted by electronic communication and good weather favoured both of these events (Tim Haymes).

An account of the Sapientia result is reported in the BAA Journal

JBAA 2015 December Vol 125, No.6 Page 331. Stellar Occultation by (275) Sapientia well seen. – Author: Richard Miles.

BAA occultations – future possibilities (Tim Haymes, BAA, IOTA-ES)

The presentation reviews how the BAA can help observers in the light of improved predictions from Gaia. Current alerting methods are summarised.

The content of the BAA Handbook (occultations) will be described briefly.

The greater use of USB planetary web cams (CCD) is to be encouraged, since many potential observers use them.

In future workshops observing sections should include the ability to measure camera delays and discuss the accuracy of the many timing and recording methods that could be employed.

Revisiting observations of the 44 Cap lunar graze of 1989 Aug 17, (Alex Pratt, IOTA-ES, BAA)

In the early hours of 1989 August 17 Andrew Elliott recorded and timed the grazing occultation of 44 Cap (magnitude 5.9) during the umbral phase of a total lunar eclipse.

On checking Andrew's timings of the D-R-D-R sequence listed in Occult4's Historical Grazes module his O-Cs were small, except for a large value for the R1 event. Plotting the events against the LOLA lunar limb data showed this discrepancy, and a review of Andrew's original videotape confirmed that a mistake had been made either when submitting his observations or when they were added to the occultations archive.

The full story of these investigations is presented, including how the erroneous timing was corrected in the lunar archive, and it concludes with a discussion about record keeping, the problems of extracting data from near-obsolete media and future-proofing archival material.

Eberhard Bredner also observed this event with Andrew and he contributed his additional comments to the presentation.

Further details can be found in:- Journal for Occultation Astronomy, 2016-1, Jan-Apr 2016, page 20-22, The Grazing Occultation of 44 Cap during the Total Lunar Eclipse of 1989 August 17, Alex Pratt.

Saturday session 2
Lunar occultations (chaired by Jan Manek, IOTA-ES)

Analysis of a Hyades double star occultation (70 Tau) using Limovie (Tim Haymes, BAA, IOTA-ES)

The Moon passed across the Hyades on 2016 Jan 19th in good conditions from the UK. This presented a number of bright total occultations, some of which are known double stars. Fl 70 Tauri gave a clear step in the light curve. I present the equipment and software used to analyse the result.

This example describes the basics of the analysis process with assistance and advice from Brian Loader and Jan Manek, and following some notes from Alex Pratt, who presented his results at ESOP XXXII Barcelona (2013).

An Historical Perspective: the Grazing Occultation of 139 Tau on 1972 March 21 (Richard Miles, BAA)

An account of a successful lunar graze occultation from the early 1970s is presented. Based on predictions by Gordon Taylor, several expeditions were organised including one in the Bristol area by Dr Rodney Hillier, a Bristol AS member who passed away recently. A report of the occultation appeared in the BAA Journal. More recently, Tim Haymes utilised Occult 4 and Kaguya data to analyse the observational results.

Occultation of the open cluster Hyades by the Moon. (Vaclav Priban, IOTA-ES, Observatory and Planetarium, Prague, Czech Republic)

First observation from a private observatory which I have constructed at my cottage near Krkonose mountains (Giant mountains, Riesengebirge). This contribution describes preparing and equipping the observatory and shows the first observed occultations of the stars by the Moon in records and conditions under which they were obtained.

A greeting from Harrie Rutten (presented by Richard Miles)

Very best regards from Harrie Rutten - Arcen, Netherlands. Unfortunately I cannot attend ESOP35 – I had a bad cycling accident which I will describe. Plans for the future include acquisition of a 16-inch ODK when my mobility and recovery have improved.

So all the best to you. Hope to see you next year.

Front : Mike Kretlow, Andrea Turner, Bernd Gährken, Oliver Klös, Alex Pratt, Martina Haupt, Jan Manek, Carles Schnabel, Konrad Guhl, Wolfgang Beisker

Middle : Frank Schaffer, Nick Turner, Astrid Teuscher-Faragó, Carsten Faragó, Adrian Jones, Sven Andersson, Vaclav Priban, Henk de Groot, Andreas Eberle, John Sussenbach, Richard Miles, Eberhard Riedel, Eberhard Bredner, Christoph Bittner

Back : Derrick Ward, Tim Haymes, John Talbot, Phil Berry, Brian Mills, Martin Burger, Nick Qinn, Niko Wünsche Len Entwisle, Phil Denyer, Jan-Maarten Winkel, David Briggs, Toni Santana-Ros. Photo Credit: Janice McClean (BAA)

Group photograph (taken by Janice McLean, annotated by Tim Haymes)

Construction and setup of a stand-alone Raspberry Pi time-server for computer time synchronisation (David Briggs, Hampshire Astronomy Group)

Recording of occultation video or CCD images requires an accurate UT time reference. This is often supplied via a continuous 1pps GPS time stamp overlaid on an analogue time signal from a video camera. When using USB digital cameras, the time signal originates from the PC clock. Synchronisation is achieved via software such as Dimension4 and a wired internet connection.

The Raspberry Pi time-server receives the GPS signal directly, and does not require an internet connection. This is advantageous where no internet is available e.g. in an observatory, or in the field.

The stand-alone Raspberry Pi time-server is not original, as most of the information is freely available on the internet. However its application to occultation astronomy is probably new. The RasPi does require a basic knowledge of Debian Linux to set it up, as well as setting up the Meinberg Windows NTP software.

The system will be explained and hand-outs provided. (Live demonstrations took place during the coffee breaks and at lunchtime).

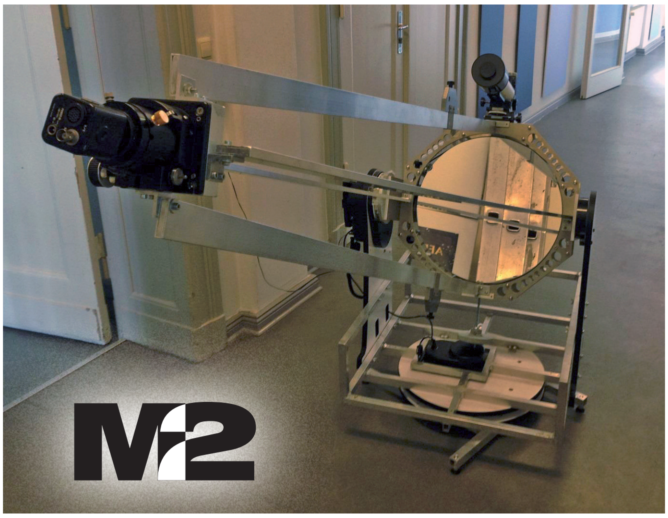
Saturday session 3
Instrumentation (chaired by Adrian Jones, BAA)

Raspberry Pi time-server Question & Answer session (David Briggs, Hampshire Astronomy Group)

Further discussions took place about this time-server solution.

A portable 20-inch telescope for IOTA/ES (Konrad Guhl, IOTA-ES, ASTW)

The observational work of IOTA is spread out across observation sites around the world. Due to focusing on occultation astronomy of TNOs and moons of the outer planets, the size of telescope necessary has increased over the years. The standard "travelling observatory" for many years – the C8 telescope (8 inch diameter) - doesn't fit the requirements of these observations any more. The signal to noise ratio of these rather small instruments cannot keep up with faint objects (up to 20th magnitude), even if highly sensitive CCD (or EMCCD) cameras are used for detection. An instrument with a diameter of 20 inches would solve this problem: from a dark observation site, with an exposure time of 1 second, an instrument of this size is able to detect occultations of stars fainter than 18th magnitude.



Therefore, IOTA-ES decided to buy a used 20-inch Dobsonian telescope in order to adapt it to the requirements of occultation work. An instrument of this size balances research capability and transportability well. The presentation will show the different stages of the project and the instrument in the final design. The first presentation about the instrument was given at ESOP XXXIII in Prague (2014). Within the last two years, the telescope was finished and improved. A first expedition was undertaken to the Alps for an occultation of a star by Pluto on July 19, 2016.

The instrument will be based in Hannover, Germany (headquarters of IOTA-ES) and will be made available to IOTA-ES members on request.

A sensitive CCD camera with timing accuracy in the low millisecond range (Wolfgang Beisker, IOTA-ES)

Based on a CCD camera from a large commercial camera company, a complete camera package has been developed and tested.

Because high timing accuracy is required in occultation observations, only a LINUX system is appropriate. The time is read in from a GPS clock with a 1 pulse per second output. This output is fed into the computer by a RS232 to USB converter, controlling an NTP protocol. The time difference of the system clock and the GPS clock is generally better than 0.01 msec.

Using a commercial software developing kit, a GUI has been programmed, which integrates all necessary parameters, input and outputs, and other human interactions.

By direct comparison between the GPS 1 pps output and the camera images an accuracy of the time stamps written into the FITS headers of better then +/ 5 msec could easily be achieved. The system is ready to be used and can be set up together without large mechanical work. Only the GPS receiver, a RS232 to USB converter, the camera, an electric fan and a notebook computer are needed.

The camera can operate with up to 30 images per second generating single FITS files. The read-out noise is around 7 electrons and the maximum quantum efficiency is around 70%.

The details of camera, hardware and software are presented.

Atmospheric Dispersion Corrector - Useful for observing low altitude occultations? - A practical test (Oliver Klös, IOTA-ES, VdS)

Light coming from celestial objects first passes through the atmosphere of our Earth before reaching the telescope. The deviation of the light depends on the wavelength and the altitude of the object above the horizon. Blue light is deflected more than red light.

Planetary observers know this phenomenon very well. A red border appears at one side of the object, a blue border on the other side. An Atmospheric Dispersion Corrector (ADC) can compensate for this effect.

But what about low altitude occultations?

The light of stars is spread out in the same way as the light of other objects. Therefore a star at low altitude appears elongated perpendicular to the horizon. An ADC should focus the light of a low altitude star on a smaller area on the detector of the camera.

Could this improve our measurements of occultations? The results of a practical test will be presented at this lecture.

Saturday session 4
Reports (chaired by John Talbot, BAA)

The Pluto occultations on 14th and 19th of July 2016 - Preliminary overview of observations (Wolfgang Beisker, on behalf of the European Pluto Occultation Team)

Two occultations by Pluto on the 14th and 19th of July have been observed throughout Europe. The first one (stellar magnitude about 16) was aimed to be the pathfinder for the central flash of the second one (stellar magnitude about 14).

Because of the favourable weather situation, many stations throughout Europe were able to observe the occultations. In an unprecedented effort, it was possible by Bruno Sicardy and his team to calculate the central line of the occultation on the 19th. The publication of the first Gaia position of the target star on the 19th by the Gaia team allowed us, in combination with the observations on the 14th, to pinpoint the central line very precisely. As it happened, the line moved farther south to northern Africa and the Canaries. In all parts of central Europe it was possible to observe the following occultation.

This report will give just a rough overview of what has been observed, without a detailed analysis.

High resolution imaging of mutual events of the Jovian satellites during the 2014/2015 apparition, (John Sussenbach[1] and Willem Kivits[2]*)

[1] Houten (The Netherlands) and [2] Siebengewald (The Netherlands)

During the Jupiter apparition in 2014/2015 several mutual occultations and eclipses of the Galilean satellites took place. These mutual events occur every 5.93 years. A number of the mutual events have been recorded using 14-inch telescopes and different types of cameras. The current processing programs like Registax 6.1 or Autostakkert2! struggle to grade, align and stack the tiny images of the Jovian satellites. To obtain high resolution images, different processing procedures were employed to optimise the quality of the images, including hand selection of the master frames. A number of occultations and eclipses were recorded at high resolution. In several eclipses the umbra and penumbra could be distinguished successfully. The most interesting mutual phenomenon was observed on 7 February 2016, one day after the date of opposition viz. the simultaneous occultation and eclipse of Ganymede by Callisto.

*Willem Kivits passed away on 23 February 2016

JBAA 2016 October Vol 126, No.5 Pages 290-296. High resolution imaging of mutual events of the Jovian satellites during the 2014/2015 apparition . – Authors: John Sussenbach and Willem Kivits.

Occultation of 8th mag star HIP 54599 by (216) Kleopatra on 12 March 2015 (Bernd Gährken, Bavarian Public Observatory, Germany)

The occultation of the 8th mag star by (216) Kleopatra was the most interesting occultation event in Germany in 2015. The weather was good and many observers got a positive result.

(216) Kleopatra is well-known from radar observations. The radar observations show an uncommon bone-shaped structure which is based on several assumptions. The occultation gave an opportunity to compare radar and reality.

Mutual events of the binary asteroid (22) Kalliope in 2016 and 2017 (Oliver Klös, IOTA-ES, VdS)

There are some very good opportunities to observe occultations by (22) Kalliope and its satellite Linus across Europe in the next few months, but other interesting measurements could be made while the binary asteroid reaches its equinox.

Several events can be expected:
Kalliope occults Linus
Kalliope eclipses Linus
Linus occults Kalliope
Linus eclipses Kalliope

This lecture presents the most favourable events for Europe, gives information about expected magnitude drops and accuracy in time and provides a link to the complete list of all events generated by Frédéric Vachier from IMCCE. http://fredvachier.free.fr/

Saturday session 5
Evening workshop (chaired by Alex Pratt, IOTA-ES, BAA)

Informal software demonstrations / tutorials

Included practical demonstrations by John Talbot (Reading AS) of OccuRec and AOTA software.

Sunday session 1
Predictions and projects in the Gaia era (chaired by Richard Miles, BAA)

Gaia – the impact on asteroid occultations, (Dave Herald, IOTA, Murrumbateman, Australia – via Skype)

The current astrometric situation is compared with what we can expect after the Gaia data releases from September 2016 to 2020. The parallax and proper motion of 1 billion stars is anticipated down to mag 20. The catalogues are also expected to contain a large number of new objects. Occultation paths will become highly refined. For stars brighter than mag 12, the path errors will be less than 20km. An observation strategy is suggested.

(This presentation was also given at a recent Paris conference, and to IOTA in July).

On the uncertainty of asteroidal occultation predictions in the Gaia era, (Mike Kretlow, IOTA-ES, BAA)

The predictability of asteroidal occultations is limited by the uncertainty of the available ephemeris and by the error of the star position given for the occultation epoch. Typical star position uncertainties are about 10 - 100 mas for star catalogues mostly used in current asteroidal occultation work. For the first data release of Gaia (G1) a mean error of ~1 mas can be expected, the final catalogue will be about 100 times more accurate.

On the other hand the current ephemeris uncertainty of an asteroid is a complex result of the astrometric data used for the orbit determination and the (iterative) computation process itself. The astrometric observations are usually an inhomogeneous set of measurements made over years or decades by different observers with different techniques and reduced with different star catalogues, and thus are affected by a wide range of random and systematic errors and even not necessarily expressed within the same reference (catalogue) system.

Current uncertainties in asteroid ephemerides are often in the range of some 10 to 100 mas at the 1-sigma level. A 500 mas ephemeris uncertainty corresponds to ~360 km cross-track displacement on the Bessel plane for an object at 1 AU distance to Earth. To achieve a significantly better prediction quality we have to increase the ephemeris accuracy as well, e.g. by debiasing astrometric observations towards a Gaia catalogue system.

The talk will address these issues and looks at the prediction uncertainty and predictability which can be achieved now, in the near future (G1) and in the post-Gaia era.

LUCKY STAR - An EU research project with Pro-Am collaboration (Wolfgang Beisker, IOTA-ES)

I will introduce and explain a new collaborative project involving professional and amateur observers.

Gaia-GOSA An interactive service for asteroid follow-up observations (Dr Toni Santana-Ros, Astronomical Observatory of Adam Mickiewicz University, Poznań Poland)

http://arxiv.org/abs/1505.03802

Gaia-GOSA is an interactive tool which supports observers in planning photometric observations of asteroids. Each user is able to personalise the observation plan taking into account the equipment used and the observation site. The list of targets has been previously selected among the most relevant and scientifically remarkable objects, while the predictions of the transits in Gaia's field of view have been calculated at the Observatoire de la Côte d'Azur. The data collected by the GOSA community will be exploited to enhance the reliability of Gaia's solar system science. The service is publicly available at www.gaiagosa.eu.I present the Gaia Ground-based Observational Service for Asteroids (GOSA).

Determination of asteroid diameters from occultations (Dave Herald, IOTA, Murrumbateman, Australia – via Skype)

I have recently been developing tools to directly determine asteroid diameters from our occultation observations, by making use of asteroid shape models.

I am hopeful that we shall soon set about reviewing all our past observations for events where a shape model is available - so that we can generate 'direct' measurements of asteroid diameters for a good number of asteroids.

The presentation will describe the techniques and problems, and some of the challenges ahead.

(This presentation was also given at a recent US meeting).

Sunday session 2 Practical techniques (chaired by Konrad Guhl, IOTA-ES)

New features of GRAZPREP, (Dr Eberhard Riedel, IOTA-ES)

With the LRO/LOLA lunar profile data as calculated by Dietmar Büttner, Germany, and provided for use in GRAZPREP it is now possible not only to increase the prediction quality but also to revise former grazing occultation reports. GRAZPREP has a special tool that allows an easy graphical checking of occultation timings against a highly enlarged lunar rim. The possibilities and limitations of this procedure are discussed.

Now shortly before the first release of the Gaia catalogue the stellar positions as well as the uncertainties related to stellar double and multiple systems are another obstacle to the precision of prediction and evaluation. According to a request of Gaia project officials, GRAZPREP will be used to confirm the precision of the Gaia positions once they are available.

Using Occult4 to report and view light curves (Alex Pratt, IOTA-ES, BAA)

A new feature in Occult4 allows the observer to submit light curves of asteroidal and lunar occultations to a publicly available dataset. Observers are encouraged to contribute the light curves from their latest observations and their work from previous years.

The processes involved in selecting light curve data and reporting the data files are presented and discussed, including the options for searching on star catalogue number, asteroid number or observer name to view light curves in the dataset.

(This presentation included additional slides contributed by Dave Herald).

UKOCL The UK occultation prediction feed for OccultWatcher (John Talbot, Reading AS)

This feed was set up in 2014 using the URAT1 catalogue. Its purpose is to provide parts of Europe, and the UK in particular, with predictions for smaller bodies of which there are many. There are some false stars in this catalogue so potential observers should be made aware of this.

The presentation will describe the selection criteria used for predictions, how it can be accessed with OccultWatcher, and observing tips when selecting these targets.

Using OccuRec – Occultation recording software by Hristo Pavlov (John Talbot, Reading AS)

OccRec is a video recorder for Windows that has been specifically created to provide better options for recording asteroidal occultations with integrating cameras.

The settings provided in the software offer useful features, and should appeal to potential users. The recording format (AAV) is written by H Pavlov and the video can be read and analysed by Tangra 3.

The main features of the software will be described from this user's point of view, together with tips on how to set it up and record from the camera, and how the recording is used to obtain a basic light curve.

Travelling and observing with small equipment (Eberhard Bredner, IOTA-ES, DOA, Club Eclipse)

"From Mars to theta Librae and nothing".

This will be basic information on the use of portable equipment. I also hope to give some hints for the more experienced observers.

Sunday session 3
Open forum (chaired by Wolfgang Beisker, IOTA-ES)

General Question and Answer session.
Overview of the proposed location of ESOP XXXVI in 2017 and future ESOPs.
Closing remarks, acknowledgements and thanks to the Local Organising Committee.
Information about the social trips on Monday and Tuesday.

Sunday session 4
Evening (chaired by Tim Haymes, BAA, IOTA-ES)

Tim showed a documentary on recent excavations at Stonehenge, as a precursor to the visit on the following day.

Occultation of a mag 10 star by (922) Schlutia

Tim had publicised this rare opportunity on Sunday night of observing an asteroidal occultation during an ESOP. The predicted shadow track passed near to the University. Poor weather conditions thwarted any plans to monitor the occultation.

Monday social trip

Delegates and accompanying persons enjoyed a coach excursion to the observatories of the Hampshire Astronomy Group at Clanfield. http://www.hantsastro.org.uk/ The visit lasted for about an hour, during which they viewed the large range of telescopes on site, including a 24-inch Ritchey-Chrétien reflector, twin-mounted 5-inch Cooke and 4.5-inch Smith Beck and Beck refractors, a 7-inch Starfire refractor and the 16-inch Newtonian used by David Briggs for asteroidal occultations and astrometry.

The group moved on to visit the famous Neolithic stone circle of Stonehenge, Wiltshire, a UNESCO World Heritage Site.

http://www.english-heritage.org.uk/visit/places/stonehenge/

In the afternoon the tour included sightseeing of Salisbury Cathedral, Wiltshire, and its original copy of the Magna Carta from the year 1215. http://www.salisburycathedral.org.uk/

Tuesday social trip

On the last day there was an excursion to Herstmonceux, East Sussex, to visit the old site of the Royal Greenwich Observatory (now transferred to Cambridge). As well as spending time in the interactive hands-on Observatory Science Centre http://www.the-observatory.org/ the visitors were given guided tours of the large telescopes in the Equatorial Group of domes. http://www.the-observatory.org/telescopes Amongst these is the 26-inch Thompson refractor, the 36-inch Yapp reflector and the 13-inch astrographic refractor which took part in the Carte du Ciel project.

An excellent ESOP!

Everyone agreed that ESOP XXXV had been a most enjoyable and productive symposium with a full social programme. The members of the Local Organising Committee, Tim Haymes, Anne Haymes, Richard Miles, Adrian Jones and John Talbot are to be congratulated.

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 December 2016, the Minor Planet Center listed 689 Centaurs and 1789 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:

(120347) Salacia

Andrea C. Guhl

DISCOVERY:

When 120347 Salacia was discovered as then-2004 SB_{60}, little was it known that this cubewano forms the larger part of a binary system. Found in September 2004 at Palomar Observatory, Henry G. Roe and colleagues reported the discovery in 2005; only for Keith Noll and his team to find Salacia’s companion moon (Actaea) using the Hubble Space Telescope in July 2006. Precovery documentations of the system were found, the oldest dating back to 1982. Despite being the darkest known TNO, a slightly red colouring has been reported (V-I=0.69).

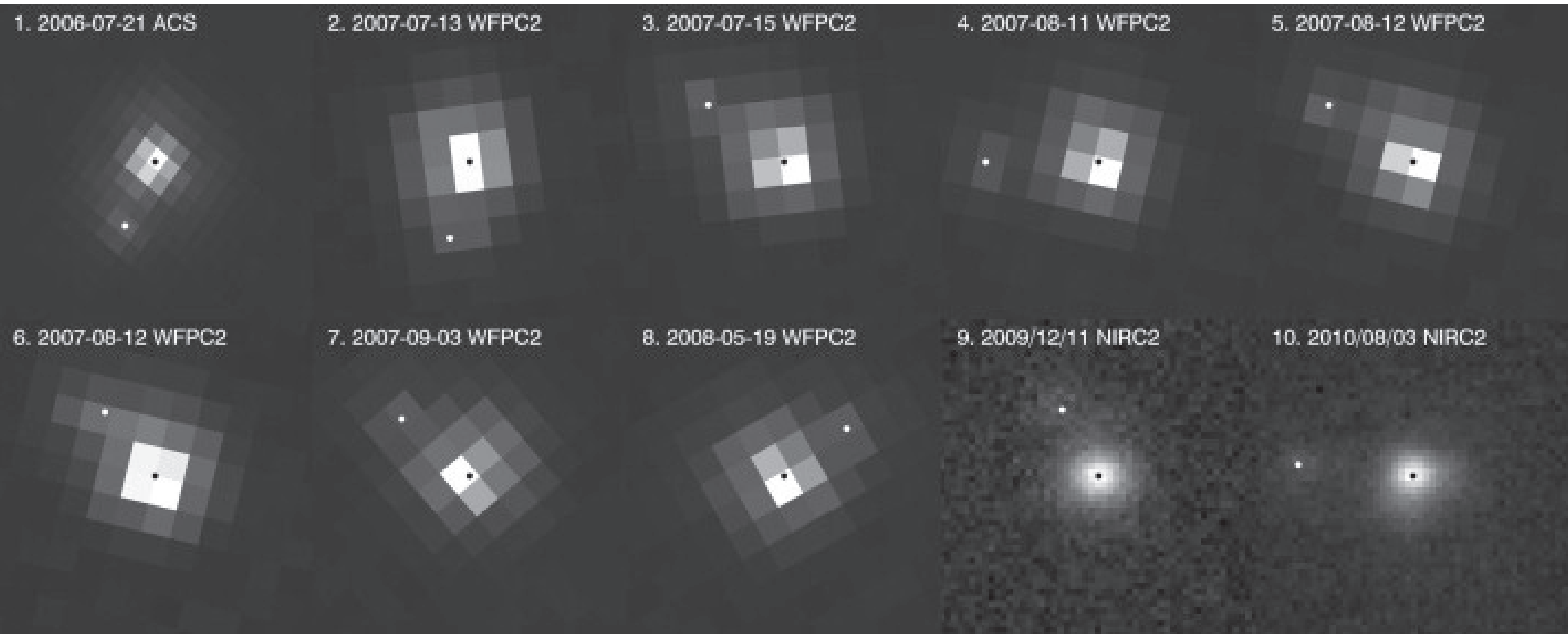


Figure 1 "A single frame from each of the 8 Hubble visits and the two NIRC2/Keck observation of (120347) Salacia-Actaea." Published in Stansberry et al., 2012

Name(s):

Oftentimes, Roman and Greek mythologies find different names for similar figures. As Amphitrite was wife to Poseidon in the Greek pantheon, Salacia was known to the romans as Neptune's queen and divinity of saltwater. Originally a nymph, she retreated to the depths of the Atlantic ocean when Neptune courted her. Grieving, he sent the dolphin Delphinus after her who convinced her to marry Neptune. Salacia's moon, Actaea, takes its name from the Nereid of the sea shore. Both names were assigned in 2011.

Known Parameters:

With a diameter of 901 +/- 45 km, Salacia is one of the largest TNOs. The accompanying moon is estimated with 286 +/- 24 km, orbiting at a distance of 0,110 ± 0,002". There is no evidence for water ice in the near-IR spectra; but a density close to water means that there should be water ice present to fit the density data. Another explanation for the low density could be a porous nature of the body. This implies an unsegregated nature; which may be untypical for bodies of this size. Salacia's albedo is particularly low (0.035 $^{+0,010}$–0,007).

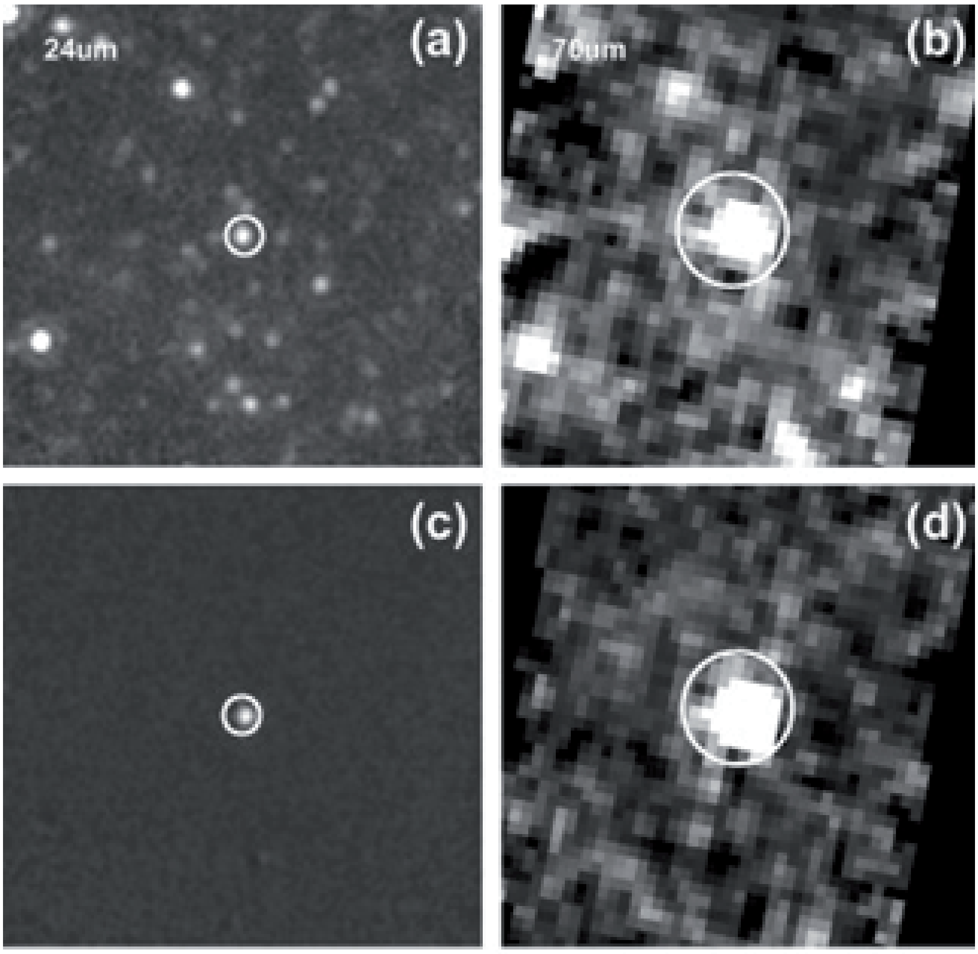
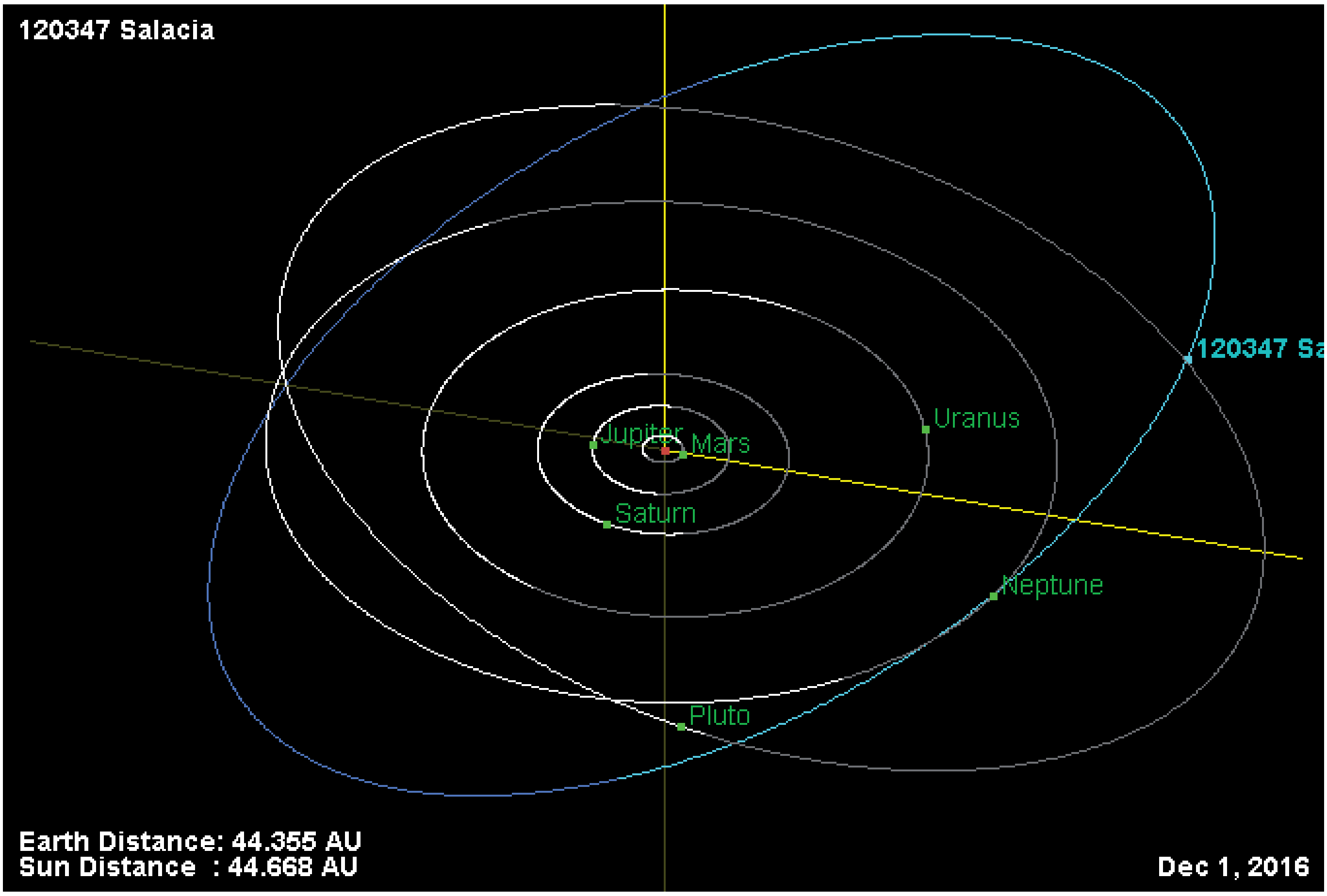


Figure 2: "Spitzer images of Salacia in 24 µm (left) and 70 µm (right) bands. Panels a) and b) show the data for Salacia resulting from a single observation; panels c and d show the final product, including sky subtraction and coadding the two observations. Circles are centered at the target ephemeris position and have radii of 8" (24 µm) and 24" (70 µm)." Published in Stansberry et al., 2012



Orbit:

The orbit is moderately eccentric with 0.107 and highly inclined at 23.9°. The aphelion distance is 46.46 AU. The graph show the view to our solar system 2016 Dec1.

Where is Salacia at this time:

From mid-December 2016 till mid-February 2017 the planet is slowly moving towards the constellation of PEGASUS as an object below 20^m.

Ephemeris made using HORIZONS

Date	R.A.	DEC	m
2016 Dec 16	23 15 25.46	+21 02 03.8	20.67
2016 Dec 31	23 15 55.40	+20 56 43.9	20.68
2017 Jan 16	23 16 48.02	+20 53 54.2	20.69
2017 Jan 31	23 17 53.68	+20 54 09.4	20.68
2017 Feb 16	23 19 16.70	+20 57 33.1	20.67

Upcoming occultation:

Needless to say – the calculation of a possible occultation requires exact astrometry and are a guess for longer prediction periods.

Using OCCULT as a first tool we find two possible occultations within the next years:

In 2017 Nov 17 a 15.4^m star will be occulted, visible in Europe and western Africa and in 2021 Oct 23 maybe the planet will occult a 12.4^m star, visible in north America. For both events exact prediction will be used for observation planning. In any case occultation would take longer than 30 sec and the usable high integration time allows observing small stars.

Occultation observation in the past:

Only one observation (C. Schnabel on 2015 Jan 04) is published but no occultation was observed.

References

/1/ Fornasier, S., et al., 2013, TNOs are cool: A survey of the trans-Neptunian region. VIII. Combined Herschel PACS and SPIRE observations of 9 bright targets at 70-500 um, Astron. and Astrophys., 555:A15

/2/Stansberry, J. A., W. M. Grundy, M. Mueller, S. D. Benecchi, G. H. Rieke, K. S. Noll, M. W. Buie, H. F. Levison, S. B. Porter, and H. G. Roe, 2012, Physical properties of trans-Neptunian binaries (120347) Salacia-Actaea and (42355) Typhon-Echidna, Icarus, 219:676-688.

/3/ http://ssd.jpl.nasa.gov/horizons.cgi

/4/ D. Herald: software package OCCULT

/5/ Mike Kretlov: occultation reports in database http://astro.kretlow.de/

Pic. 1, iridescent clouds during occultation, Iridescent clouds.

Baily's Beads Observation

during the annular eclipse 2016 Sept. 1

Konrad Guhl (IOTA/ES) Andreas Tegtmeier (IOTA/ES)

General

For many years now, the observation of Baily's beads has been one of the main activities of IOTA and IOTA/ES. These endeavours addressed a detailed determination of the solar diameter as well as the detection of possible variations. Following an agreement met at ESOP XXXI (2012, Pescara, Italy), the measurement program will end in 2017 as a reaction to spacecraft observations going on since 2012. While spacecraft observations have a higher precision than Baily's beads observations, a 5-year overlap in data sequences of both methods was deliberately planned after the start of the PICARD-mission.

In 2016, IOTA/ES organised an expedition to the edges of an annular eclipse September 01, where the bead observation was also possible. In addition, observers from the US recorded this event, a separate report is expected. The eclipse path ran from the Indian Ocean to the Atlantic Ocean crossing touching La Reunion, crossing Madagascar and the African continent. Due to travel and weather situation, Madagascar and Tanzania were selected for the observation.

Instruments and reduction method

The equipment used follows the IOTA/ES recommendation and based on a 100/1000 mm Maksutov-optic, a non-automatic camera, a 535 nm-filter and the IOTA/ES filter (see /1/). The analog video signal with an inserted GPS time signal was digitalized and recorded as AVI-file by laptop computer.

The video file has been visually analysed by the authors. The inspection was done twice on different machines and occasions. Only beads, easy to identify are entered in the table of results. After clear identification, the Watts angle is found by the eclipse simulation software /3/. Following the data table format of /1/, the observations are listed in table 1 and 2. According to station nomenclature proposed in /1/, the stations are called 2016MDN1 and 2016TZS1.

Northern station 2016MGN1 (Carmen and Andreas Tegtmeier)

As described above, we have selected Madagascar for observing the northern rim due to better weather conditions and better accessibility. On the west coast, the probability of clouds was the least, since clouds usually form to the east above the Indian Ocean and shed their rain at a mountain range parallel to the east coast. 18 km north of the provincial capital Mahajanga (a port town with about 160,000 inhabitants on the channel of Mozambique), we found the ideal observation space on a small dirt road for undertaking the observation.

Unfortunately, the weather conditions were unfavourable, since it was very cloudy at first (we needed 2 hours to set up the equipment). Thankfully, there was a large cloud gap for 5 min at the observation time (about 09.40'00 UTC), in which we could make the recordings.

Due to the clouds we were able to capture some beautiful light effects between the 2nd and 3rd contact with iridescent clouds (see picture 1).

Position of 2016MGN1:
Latitude 15°35′ 9.7″S; Longitude 46°25′7.9″E; h=50 m (WGS84)

Southern station 2016TZS1 (Elke and Konrad Guhl)

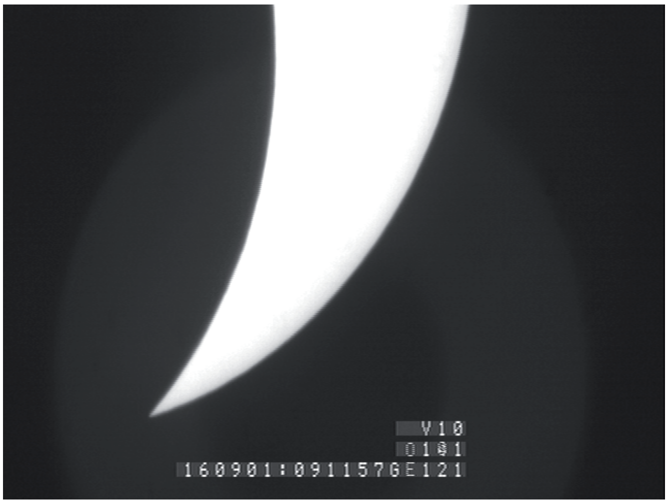
The southern edge of the annular zone touches the continent Africa in northern Mozambique. In the south eastern region of Tanzania, clouds are to be expected due to the influence of the Indian Ocean. Based on weather/cloud statistics of 2014, the IOTA/ES member Roman Kostenko travelled to southern Tanzania to inspect the landscape and roads for an expedition to the eclipse. He recommended the region north of Mbeya. Since this region is somewhat detached from major tourist areas, which are easy to reach such as the Serengeti Park. Mbeya itself is a commercial region with trading, education and mining. The observation place was appr. 20 km north of Mbeya city, in the mountains.

Sky and visibility were perfect, just a little windy (3 to 4 bft).

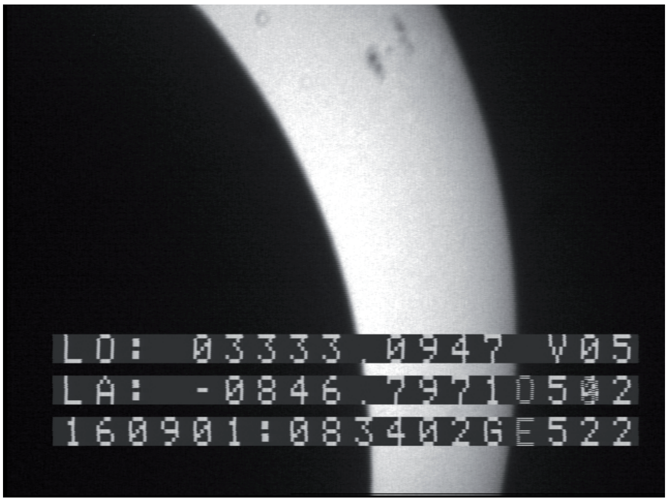
Position of 2016TZS1: Latitude 8°46′ 7.8″S; Longitude 33°33′5.7″ 7,268′E; h=2000 m (WGS84)

Reduction and preliminary result

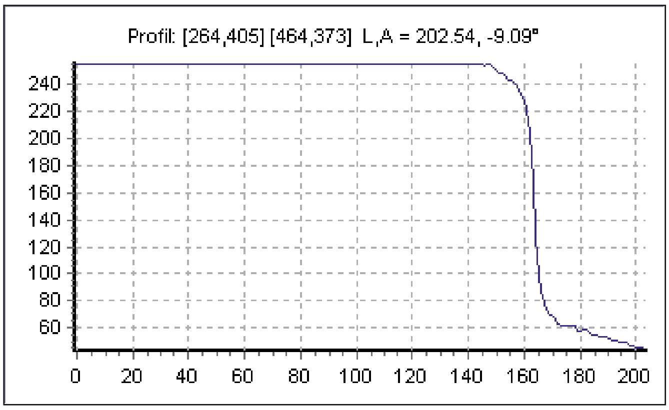
Following /5/, the limb darkening function of the video observation is analysed in a video frame during the partial phase (picture 2 and 4).



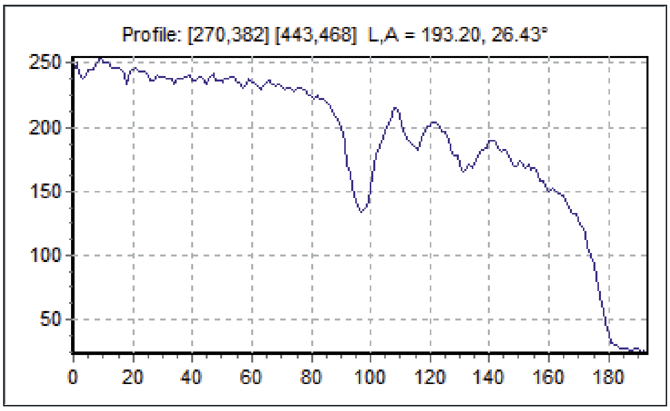
Pic. 2, video frame during the partial phase for focus control and determining brightness profile, station2016MGN1.



Pic. 4, video frame during the partial phase for focus control and determining brightness profile, station 2016TZS1.



Pic. 3 brightness profile station 2016MGN1



Pic. 5 brightness profile, station 2016TZS1


Northern station 2016MGN1 (Carmen and Andreas Tegtmeier)


Southern station 2016TZS1 (Elke and Konrad Guhl)

Pictures 3, 5 and 6 show profiles of brightness over the radius. Picture 5 is a traverse through a group of sunspots, picture 3 and 6 show the profile of the photosphere without visible disruption of both stations.

All observations are simulated with the software tool „Baily Bead Analysis"of the software /3/. The version V 4.2.5.0 includes the Kaguya data. Thus, the analysis was done using this method only; all other simulation/calculation tools e.g. SUNBEADS still use the old Watts data. The simulation shows the distance of moon limb (based on Kaguya data) and the calculated sun radius in arc-second per watts angle. So the offset of solar radius is given as output data. All data points are presented in table 1:

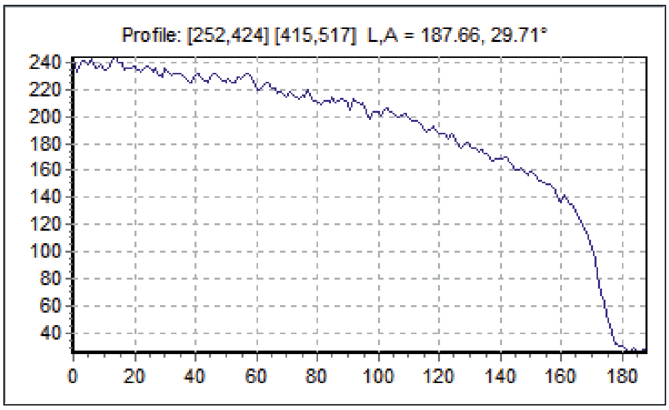
2016MGN1			
time UTC	Axis Angle	Art	Variation Solar radius Δr_S
09:39:33,4	265,6	R	-0,05
09:39:41,2	259,2	R	-0,07
09:39:51,5	248,0	R	-0,03
09:39:58,2	237,3	R	-0,02
09:40:18,4	220,0	R	0,03
09:40:20,9	216,9	R	-0,02
09:40:25,8	205,5	R	0,00
09:40:37,0	197,3	R	0,03
09:41:00,0	177,0	D	-0,07
09:41:03,4	163,1	D	0,00
09:41:05,6	171,4	D	0,05
09:41:15,6	145,0	D	0,00
2016TZAS1			
time UTC	Axis Angle	Art	Variation Solar radius Δr_S
08:49:33,5	359,1	R	-0,04
09:49:35,8	356,8	R	-0,05
09:49:46,5	352,2	R	0,01
09:50:42,9	12,5	D	-0,04
09:50:53,7	10,3	D	-0,04

The average value for Δr_S station 2016MGN1 is -0,012" +/- 0,038

The average value for Δr_S station 2016TZS1 is -0,032" +/- 0,023

The correction of solar diameter is -0,04". The observed solar diameter is close to the standard value, a little bit smaller than the official value of 959",63.

The measurement is done in a time of decreasing solar activity close to minimum. In /6/ the average of measured solar diameter from eclipse observation from 2010, 2012, 2013, and 2015 is give as 959,99 +/- 0,06".



Pic. 6 brightness profile without disruption, station 2016TZS1

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/1/ Sigismondi et. al. "Baily's Beads Atlas in 2005 - 2008 Eclipses", Solar Physics, Volume 258, Issue 2, pp 191-202.

/2/ Konrad Guhl, Andreas Tegtmeier: Baily Bead observation during the annular eclipse 2010 January 15, JOA 2011-3

/3/ D. Herald "WinOccult V 4.2.2.1. software tool

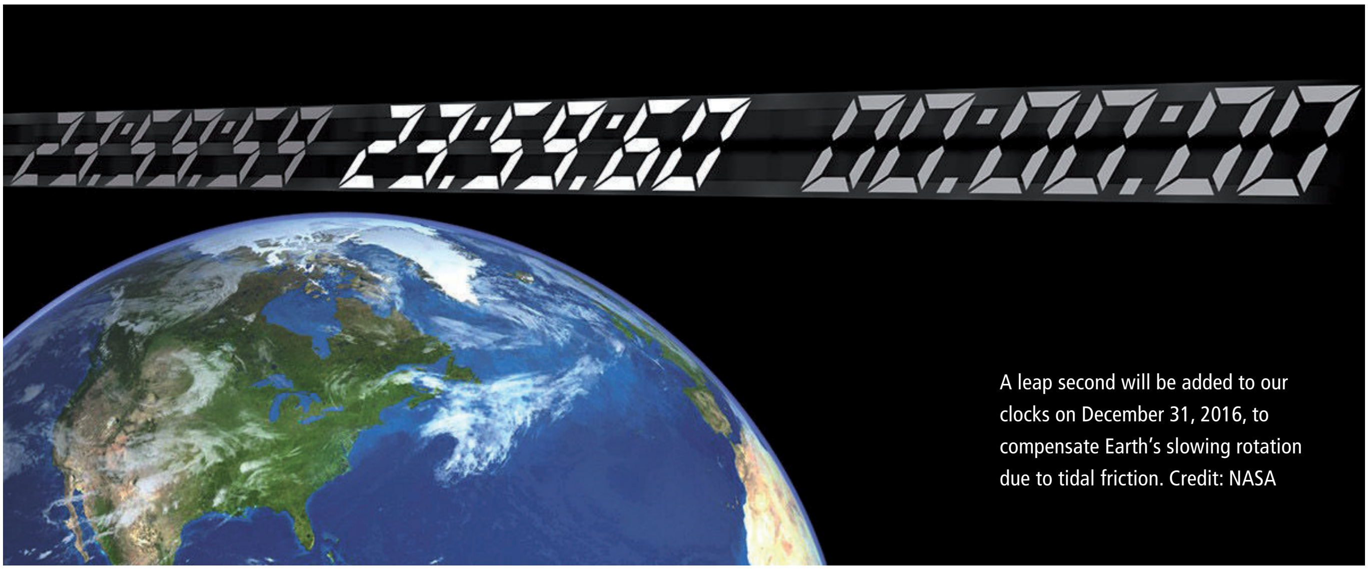
/4/ Andersson, Guhl, Haupt: "Sonnenstrahlen im Kiselevka Tal – eine erfolgreiche Expedition der IOTA/ES", Journal für Astronomie No.30 S. 70-72 and No. 31 S. 96 -99, Heppenheim 2009

/5/ Raponi et. al. „Solar limb darkening function and solar diameter with eclipse observations" EAS publication series, Nice 2012

/6/ J. P. Rozelot et.al. "A brief history of the solar diameter measurements - a critical quality assessment of the existing data" Proc. International conference on "Variability of the Sun and sun-like stars: from asteroseismology to space weather", Baku, Azerbaijan, 6 - 8 July 2015, ed. J.-P. Rozelot, Lecture Notes in Physics, Springer (Heidelberg), in the press.

Leap Seconds

Mike Kretlow, IOTA/ES, mike@kretlow.de



A leap second will be added to our clocks on December 31, 2016, to compensate Earth's slowing rotation due to tidal friction. Credit: NASA

As announced by the International Earth Rotation and Reference Systems Service (IERS) in its Bulletin C52 on July 6, 2016, a leap second will be added on December 31, 2016. This extra second will be added after 23:59:59 UTC [Fig. 1]. Thus, from 2017 January 1, 0h UTC, until further notice, the difference between UTC and the International Atomic Time (TAI) will be TAI - UTC = 37s. Most practical problems and applications in dynamical astronomy make use of the Terrestrial Time (TT) as (continuous) time scale. TT is a uniform time scale, based on the SI-second, which is currently defined and realized by the International Atomic Time (TAI): TT (TAI) = TAI + 32.184 s. Thus, the difference between UTC (clocks, observation timings) and TT (theory, calculations) is important and has to be taken into account (in programs etc.).

Leap seconds have been added 26 times since UTC replaced GMT in 1972, the most recent ones were added June 30, 2015 and June 30, 2012. The latter one caused some computer issues, especially Linux based servers and (web) services had problems (deadlock bug). In fact, the leap second concept has pros and cons and is discussed by scientists and organizations since the IERS distributed a questionnaire about Coordinated Universal Time (UTC) in 1999. But the scientific community has failed to achieve an agreement on this topic, in 2015 the decision was (again) deferred to 2023. The crunch question is: should we adjust our clocks to the Earth's slowing rotation or to uniformly ticking atomic clocks?

Why do we need a leap second?

The time unit (second) has been for long defined on base of the daily rotation of the Earth. This changed in the 1950ies, when the second was defined using atomic clocks. Thus, two alternative time scales were in use:

- International Atomic Time (TAI), a high-precision (physical) time scale realized by a network of atomic clocks.
- Universal Time 1 (UT1), an astronomical definition based on the motion of the Sun in the sky, a modern redefinition which replaced the older concept of the Greenwich Mean Time (GMT).

These two time scales did not match up exactly over time, because tidal friction within the Earth is (on a long-term scale) continuously slowing down the rotation of our planet (over the past 50 years, the measured variation was between -1 and +4 milliseconds per day compared to atomic time day). Thus, as precise time reference to be used for civilian time, a third definition was introduced as practical compromise: the Coordinated Universal Time (UTC), which is defined such that

- the difference UTC – TAI is always an integral number of seconds.
- the difference UTC – UT1 never exceeds 0.9 seconds.

This is realized by inserting (or deleting) an UTC leap second whenever UTC and UT1 drift apart by more than half a second. UTC "ticks" uniformly in SI-seconds (like TAI), which is technically desirable. On the other hand the coupling to the day-night-rhythm remains preserved, which is also important for a civil time scale. Nevertheless, there are problems associated with the leap second and therefore the scientific community is searching for alternatives.

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IERS Bulletin C (leap second announcement), 2016 Jul 06.
https://datacenter.iers.org/eop/-/somos/5Rgv/latest/16

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.

The Offices and Officers of IOTA

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Press date JOA 2017-1: Mid End of February 2017

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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.

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