Journal for Occultation Astronomy

INTERNATIONAL OCCULTATION TIMING ASSOCIATION

2017–02

IN THIS ISSUE:

M2

The 50-cm, f/4, "M2" telescope in the current mechanical configuration. Attached at the prime focus is the Raptor Merlin EM247 CCD camera.

Dear reader,

our Journal for Occultation Astronomy is now in its seventh year. 23 issues have been printed up to now. But I feel, that its impact in the world of science is still very small. There have been reports from observations, from technical equipment and from conferences as well in the JOA. But beyond the community of IOTA it is more or less not known, despite the effort, the writers of articles have spent.

If we want to enhance its impact, it is important that the scientific community can find and cite our articles. If someone is looking for astronomical information on occultations, he may not find our articles. If you "google" some terms, yes the JOA is cited there. But many scientists are not so often "googleing" subjects, but they look in their scientific information databases. And this is at first the "SAO/NASA Astrophysics Data System" ADS. Abstracts from nearly all publications of relevant astronomical articles of journals can be found there. But our JOA can not be found there up to now!

I think, its time to change this. It requires first to solve some more or less technical issues, but finally we need an abstract to be sent to ADS for each published article. The quality of the abstract decides, if someone gets interested in reading the full article. Therefore, this is not just a necessary text, just because the editors want to have it. It is like an advertisement to the scientific community to focus on reading the full paper.

Therefore, starting from the next issue 2017/3, abstracts are required for a publication in our JOA. The writers of the papers have to do this in the future. The team of editors will prepare everything else, that the JOA can be found in the ADS database system as soon as possible.

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In this issue:

Writing articles for JOA:

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

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
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Name of the author should be written in the 2nd line of the article, right after the title of the article; a contact e-mail address (even if just of the national coordinator) should be given after the author's name.

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A Renaissance of Lunar Occultations

Dietmar Büttner, IOTA/ES

1. Introduction

In the early days of the IOTA (i.e. from 1975 onwards) lunar occultations were the main subject of IOTA's efforts. This could be seen symbolically in the logo at the top of each 'Occultation Newsletter' (ON) issue: The Moon just before hiding a star. In the course of the years further new exciting topics joined leading apparently to a decreasing interest in lunar occultations, shown optically by another logo of the IOTA and of the ON.

Finally, during the last years lunar occultations were considered to have no scientific value any longer. It was thought, that all the topics of previous lunar occultation analyses were known sufficiently precise enough. In late 2016 suddenly a paper by L.V. Morrison and co-authors cast a quite new light on lunar occultations indicating that lunar occultations still do have a scientific importance in our days and probably even in the future. See [3].

A comprehensive review of the situation with lunar occultations in the past and now is given in this article.

The explanations on some basics certainly may be known to most of the readers. Nevertheless, they should be given here as a short introduction for new readers, because they are important for the understanding of some aspects concerning the scientific value discussed later.

2. Some basics on lunar occultations

If, as seen from a particular site on the Earth's surface, the Moon moves in front of a star a so called 'lunar occultation' does happen. Hence, lunar occultations are occultations of stars by the Moon seen from the Earth.

An occultation has two phases: At the moment when the star is exactly at the preceding limb of the lunar disc the star becomes invisible. That phase is called 'disappearance'. Respectively, when the Moon has moved a certain distance along its way and the star becomes visible again at the following lunar limb, that phase is called 'reappearance'.

Depending on the lunar phase either the disappearance during waxing Moon or the reappearance during waning Moon occurs at the dark lunar limb and can be observed surely. The other phase happens at the bright limb and can't be seen visually or registered by a camera, except for only very bright stars.

Because the Moon doesn't have an atmosphere and because a star has an infinitesimal diameter, an occultation disappearance or reappearance occurs practically instantaneous.

The two phases explained above are the usual case with the so called total lunar occultations. However, there are two very special cases with each lunar occultation. These occur at the northern and the southern limits of the zone at the Earth surface for which an occultation takes place. From sites exactly on these lines the disappearance and the reappearance theoretically merge into one single event when the (theoretical ideal circular) lunar disc just grazes the star for one moment with a theoretic duration of zero. A so called grazing occultation does occur. Due to irregularities of the lunar limb at sites in the very near to the limit lines the star can be seen several times to disappear and to reappear when It is behind or between lunar mountains.

Outside the limits no occultation does occur and inside a total occultation does happen.

Occultations are events depending on the positions of the star, of the Moon and of the observer. The relation of all these positions to each other decides on whether an occultation does occur at all, where it is visible and at which moment it takes place. At the instant of an occultation these positions are in an exactly defined relation to each other. This makes lunar occultations in general and grazing occultations especially useful for various scientific astrometric analyses. For more details see [5].

3. The subject of lunar occultation observations

Considering the special geometric constellation during a disappearance or reappearance described above and further considering the instantaneous character of these two phases, the classic matter of an occultation observation is to determine the moment of each contact event as precisely as possible and to relate it to the UTC time scale. This holds for total occultations as well as for grazing ones. Such timing observations have been done visually for several centuries. However, the direct involvement of the observer in the measuring process introduces unavoidable subjective uncertainties which causes a limitation of the achievable timing accuracy. In our days much more precise timings are possible by observing with video or CCD devices avoiding subjective errors. However, it should be said that the vast majority of the occultation timings available for scientific analyses today are still from visual observations. This is due to the long lasting era of visual observations.

Another subject of occultation observation concerns very close double stars. Many double stars have components so close to each other, that they can't be resolved by other means. Thanks to the specific geometry of an occultation (especially with nearly or perfectly grazing occultations) such very close double stars can be detected or measured, when each component causes an own distinct occultation event. In some cases this is possible (with a limited accuracy) even visually.
In case of grazing occultations the subject of observing is (besides a precise timing) to find out whether an occultation took place at all, and to determine the number of contacts having occurred at a particular site. This was especially worth in former decades with a much poorer knowledge on precise stellar and lunar positions and on the lunar limb profile than today. In principle, that subject is valid even today with much more accurate astrometric data available. In this field, visual observations were quite sufficient in the past, and they do continue so with a limited value in some cases even in our days.
Finally, the most sophisticated subject of an occultation observation is to record a light curve. Even if occultation events do occur nearly instantly, their progress lasts a certain time span of a few milliseconds. This can be traced with a sufficient time resolution using modern electronic means (video, CCD). Such a light curve shows the change of the stars brightness against the time. This allows to determine the star's diameter, which is (although very small) greater than zero.

4. From the history of observations and their usage

Speaking on the scientific usage of occultation observations it is necessary to consider the whole chain:

- computing and distributing the predictions
- making, reporting and collecting observations
- reducing the observations and giving a first feed back to the observers
- analyzing the reduced observations

As the predictions, reductions and analysis work requires a lot of complex and highly precise calculations as well a considerable amount of specific knowledge, this work was a domain of professional institutes over many decades. Most of this work was performed at the Her Majestic Nautical Almanac Office (HMNAO) at the Royal Observatory Greenwich, at the U.S. Naval Observatory (USNO) in Washington and at the International Lunar Occultation Center (ILOC) in Tokyo.
Beginning at about 1980 cuttings in public budgets in many countries led to a reduction and finally to cancellation of this supposed 'useless and needless' work at these 'official' instances.
Contrary to this, the observations have been a domain of interested amateur astronomers from the early days of occultation work till today. This is mainly due to the fact, that doing an occultation observation is quite an easy thing, requiring only a modest equipment and only a short expense of time.
This was one reason why IOTA was founded, namely to coordinate the work by the many amateur observers spread out around the whole world.

After shutting down the computation work described above, which was previously done by public paid institutes, this work was taken over by the IOTA completely. On the one hand, this is possible due to the technical development with powerful computers available to everybody and due to the availability of the Internet. On the other hand, this is only possible thanks a handful of very dedicated amateur astronomers within IOTA who do spent most of their spare time to perform this task!

5. The current situation concerning the practical occultation work

In our current days the conditions for a convenient occultation work with a valuable outcome are as comfortable and success promising as they were never before:
There are highly precise astrometric basic data which are mainly derived from a lot of scientific observations provided by space probes and Earth's satellites.
Firstly, these are the actual planetary and lunar ephemerides DE 430 by the Jet Propulsion Laboratory (JPL) and the stunningly precise star positions in the Gaia catalog derived by the European Space Agency (ESA).
Furthermore, there are several sets of most accurate high resolution lunar limb profile data, which were derived from the Kaguya and the Lunar Reconnaissance Orbiter (LRO) Moon probe observations. This work was done by the IOTA members Mitsuru Soma, David Herald and Dietmar Büttner independently and confirming each other quite good despite some minor differences.
For the direct use by the observer there are two highly developed PC programs for the whole process of predicting occultations, keying in the observations, checking, displaying and reporting them to IOTA. These are the programs OCCULT by David Herald and GRAZPREP by Eberhard Riedel. Both programs can be downloaded freely. They can be rated as 'state of the art' software of highest quality with a history over several decades.
Continuing with the operations by the observers, there are most precise data on their topographic positions and on the time scale UTC available by the GPS system. Additionally, the topographic mapping Internet resource Google Earth allows to display the predicted grazing occultation limit lines as well as the observer positions comfortably.
In the field of hardware a large variety of affordable transportable telescopes and highly sensitive CCD cameras is available. There are specific devices (time inserter) which perform the GPS position and time informations to be recorded correctly in the files with the photometric CCD observation.
For the reduction of occultation light curves observed by CCD cameras, there are two powerful programs named Limovie (by Kazuhisa Miyashita) and Tangra (by Hristo Pavlov). Here again, a lot of developing work for cameras, time inserter and reduction software was done by dedicated amateur astronomers.

6. The todays conditions for scientific analysis work

Besides the general conditions mentioned above (powerful computers, Internet etc.) there is one most valuable source for future scientific analysis work concerning lunar occultations: The collection of all known observations. This was compiled by several IOTA members under the leadership of David Herald using a large variety of data sources. Main resources have been the huge data sets collected at the HMNAO and at the ILOC as well by the IOTA. The special merit of the authors is to have brought all observations to one unified system, to check them for consistency, to correct any errors detected and to make them available for the interested public. All available observations from 1623 onwards to the present are included. As a result of this very huge, complex and often detective work a total of 461.692 observations was collected in that database, including 67.246 grazing occultation contact timings. These numbers are valid as per September 2015, and the database is updated regularly with new observations. The complete set with data on the timings, observers, observing sites and reduction results is available from the website of the Stellar Data Center Strasbourg (CDS) via the database vizier. See [1]. This is supplemented by another CDS database containing 'Occultation lights curves'. See [2].

7. Some general aspects of the scientific value

As mentioned above an occultation depends on the positions of the star, the Moon and the observer. A view more inside reveals a rather complex geometric and dynamic nature of these things in a 3D space. The position of the Moon is essentially the position of the point at the lunar limb at which the occultation occurs. This depends on the position of the Moon in its orbit around the Earth and on the geometry of the lunar surface at that limb point on the lunar disc as seen from the observer. And the position of the observer depends on its position at the Earth's surface and on the rotation of the Earth.
All these positions are defined in different reference systems which need to be linked to each other. Moreover, these different particular reference systems have different representations to make them accessible practically.
Each lunar occultation is an unique event which will never repeat under exactly the same circumstances (star, point at the lunar limb, …). This makes each particular occultation observation such valuable.
Grazing occultations provide a special opportunity for astrometric investigations, because they are highly sensitive against even very small differences in the positions of the bodies involved. Already graze observations made at only one site make it possible to fit the observed contacts to the predicted profile and, thus, to derive an astrometric result.
As with so many other types of observations and experiments in all sciences there are two general ways of scientific analyses. The one are statistic analyses considering a great number of comparable observations. In case of lunar occultations: many occultations of many stars observed by many observers at many sites on many dates. This is the typical way for astrometric studies. The other way are case specific analyses concerning one particular observation of one particular object or event by one single observer at one single date. Typical examples are analyses of grazing occultations as described above or of single occultation light curves recorded by CCD or video devices.

8. The scientific value in the past

In the past lunar occultations mainly have been used in various astrometric investigations. Always, the first step for this is the computation of the so called residual for each single observation. The residual O-C (observed minus computed) is the theoretical distance between the the star and the lunar limb. It should have the value zero as the star disappears or reappears just on the lunar limb in that moment. Practically, the residual has a small value different from zero with the order of magnitude of a few 0,1 or 0,01 arc seconds. All astrometric investigations of lunar occultations are aimed to find out which of the following influences caused which particular part of the residuals total amount. In detail lunar occultations have been used for:

- improving lunar ephemerides
- improving star positions and proper motions
- improving the knowledge on the lunar limb topography, necessary in the analysis of Baily's beads observations from solar eclipses
- detecting close double stars and determining their astrometric parameters
- deriving values for the fluctuations in the Earth rotation
- improving the knowledge on the linking between various time and coordinate reference systems

As there is a considerable number of variables and a vast majority of several hundred thousands of observations over a time span of several centuries, all these analyses clearly have a statistical nature.
Thanks to the high resolution photometry with video or CCD equipment another field of investigations became possible during the last years, namely the determination of stellar diameters, especially in case of nearly grazing occultations due to the extended time scale with these type of events.

9. The analysis published in 2016

One of the professional astronomers having analyzed lunar occultations in the past at a high extend was Leslie V. Morrison at the Royal Greenwich Observatory then.
Just this author together with two co-authors working at the HMNAO and at the University of Durham surprised the 'occultation society' with an article presenting another analysis in late 2016. See [3].
They used 'New compilations of records of ancient and medieval eclipses in the period 720 BC to AD 1600, and of lunar occultations of stars in AD 1600-2015' to investigate long term changes and 'variations in the Earth's rate of rotation.'
Besides timed and untimed observations of solar and lunar eclipses just the lunar occultation data from the archive mentioned in [1] were used in this study. The authors found that the 'tidal braking in the Earth-Moon-Sun system… alone does not account for the observed deceleration in rotation over the past 2700 years. A smaller accelerative component… is also present. Additionally, an 'evidence is found for (…

quasi-periodic...) fluctuations in the rate of rotation on a time scale of centuries to millennia… After AD 1600, timings of lunar occultations of stars provide the most accurate measure of the Earth's rotation on time scales longer than about a year, until the introduction of the atomic time scale from 1962 onwards. A recent compilation and reduction of all the occultation observations has enabled us to refine previous results for the decade fluctuations in the Earth's rotation.' The results are 'in agreement with investigations by other authors.'

This shows impressively how observational data received from various types of events spanning a historical long period can be combined to each other. Furthermore, this allows to independently confirm results received by other methods in modern scientific analysis work.

10. The possible scientific value in the future

All the resources (e.g. precise astrometric data, powerful computers, a bulk of historical occultation observations) available now do allow quite new astronomical questions which do exceed the previous investigations in quality and quantity by far. For instance, supplementing the historical observations with modern high precision observations could allow analyses of changes over long time spans. This could make the older observations valuable once again even if they may seem less useful today because of their limited accuracy compared with modern standards.

Besides the subject of the Earth's rotation (see [3]) there are three further fields of possible scientific use of lunar occultations in the future:

a) double stars (discover new close double stars, confirm or exclude previous double star data, improve data on double star distances, position angles and component magnitudes)

b) stellar diameters (measuring, confirming, improving)

c) high precision astrometry using grazing occultations (perhaps)

All these tasks do require high precision observations with video or CCD cameras. Obviously visual observations seem no longer valuable for this, except perhaps for a few special cases with grazing occultations.

11. Some typical problems in analyzing occultation observations

In the following a few typical problems in reducing and analyzing lunar occultation observations are described shortly.

One major problem is the correct identification of the star observed. Mainly, this is a problem in case of close double stars where the identification of the correct components is a rather complex matter. Moreover, a problem arises when the report of the observation uses the stars number in one star catalog, and the position of the star should be taken from another catalog. Cross referencing between several star catalogs is often a critical source of pitfalls.

Another common problem is the lower positional accuracy of very bright stars compared with more accurate positions of fainter stars.

The next serious problem is caused by uncertain proper motions. This is especially critical with new star catalogs, where stars have highly accurate positions at the epoch of the catalog, but have comparably rather uncertain proper motions due to the short time span of the observations on which the catalog is based.

Even if the accuracy level of astrometric work is much higher today than in the past, such general problems have 'survived' and do introduce uncertainties in the various fields of astrometry, either occultations or other. They may be identified, corrected or at least smoothed out only by statistical evaluations for a great number of observations. Thus, as many precise occultation observations as possible do continue to be needed.

12. Final remarks

There is no real reason to don't continue in observing lunar occultations. Perhaps an observation could seem to be NO LONGER valuable today. However, it also could be NOT YET valuable today. And it could possibly become valuable in the future again if even more precise astrometric basic data are available or if new questions to be solved do arise.

Thus, lunar occultation observations should be continued, in fact always with the highest achievable precision.

As a summary consider these rules which are meant seriously, even if they may sound a bit funny:

An occultation observation not performed can not be analyzed.

Observations are to be replaced by observations only.

Only an occulted star is a happy star.
Only an observed occultation is a happy occultation.
Only a reported observation is a happy observation.
Only a collected report is a happy report.
Only an analyzed set of collected data is a happy set of collected data.
Only a published analysis is a happy analysis.

And last but not least:

Apart from all scientific value, occultations are attractive astronomical events.This is nicely expressed by the subtitle of the article by Eberhard Riedel in [4]: 'A field of professional astronomy between science and beauty'.

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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 June 2017, the Minor Planet Center listed 706 Centaurs and 1815 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:

(20000) Varuna –
a quickly rotating spheroid

André Knöfel

Discovery

November 28, 2000. Observer R. S. McMillan was manually blinking the photographs of the Spacewatch 0.9-meter telescope of the Steward Observatory on Kitt Peak (Arizona), and found a relatively slow-moving object of a brightness of about 20^m. On November 30 and December 1, this object was confirmed with the same telescope by J. A. Larsen. A Minor Planet Electronic Circular (MPEC 2000-X02) [1] was published by the Minor Planet Center. The object got the preliminary designation »2000 WR_{106}«

Archive search

A group of amateur astronomers, including the author, started looking for old plates in online-archives with the tracks of newly discovered Near-Earth-Objects as well as main belt asteroids. Using a self-written software, potential plates were found including data of the orbit of the object.

The first preliminary orbit of 2000 WR_{106}, published by the Minor Planet Center, suggested the object at a distance of 43 AU from the Sun. With an apparent magnitude of 20^m at this distance, the object would be one of the brightest known Trans-Neptunian Objects other than Pluto and its satellite Charon. Thus, Reiner

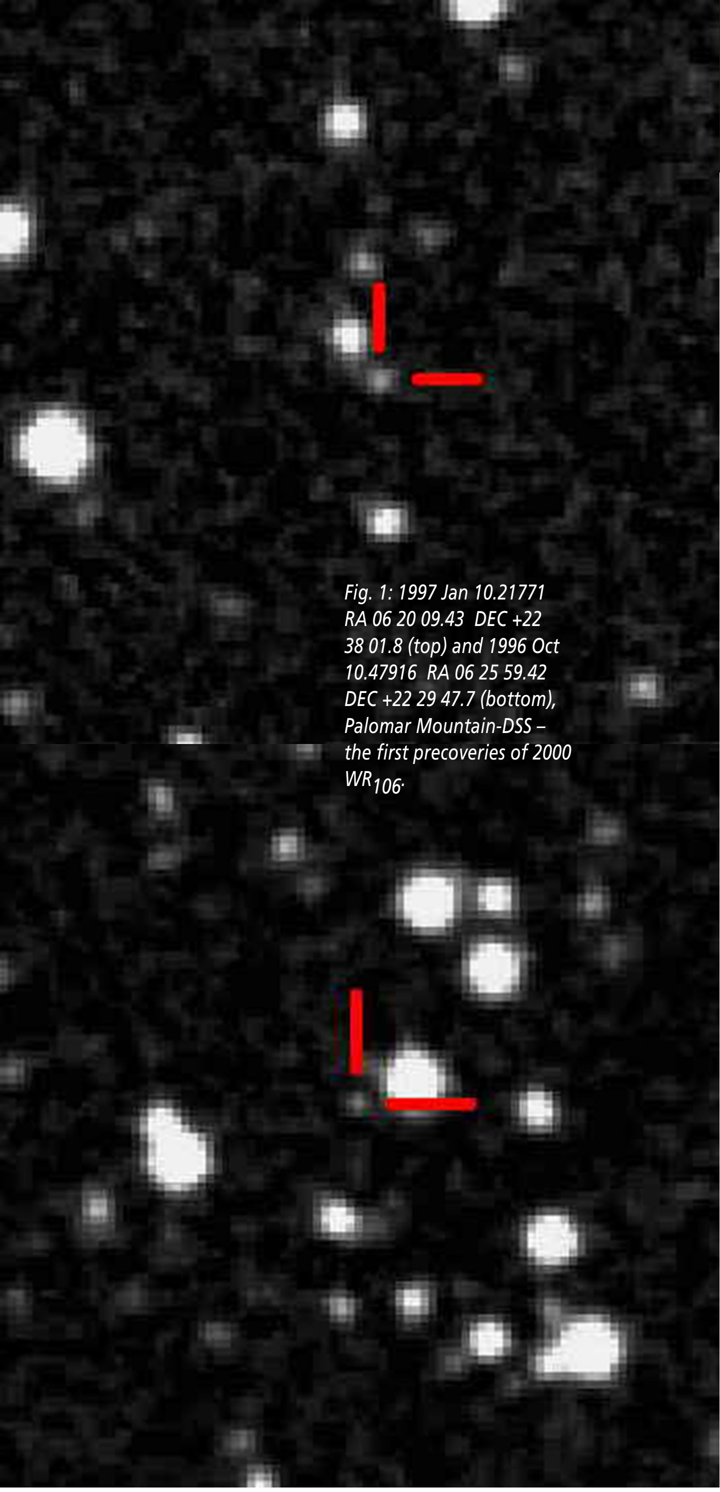

Fig. 1: 1997 Jan 10.21771 RA 06 20 09.43 DEC +22 38 01.8 (top) and 1996 Oct 10.47916 RA 06 25 59.42 DEC +22 29 47.7 (bottom), Palomar Mountain-DSS – the first precoveries of 2000 WR_{106}.

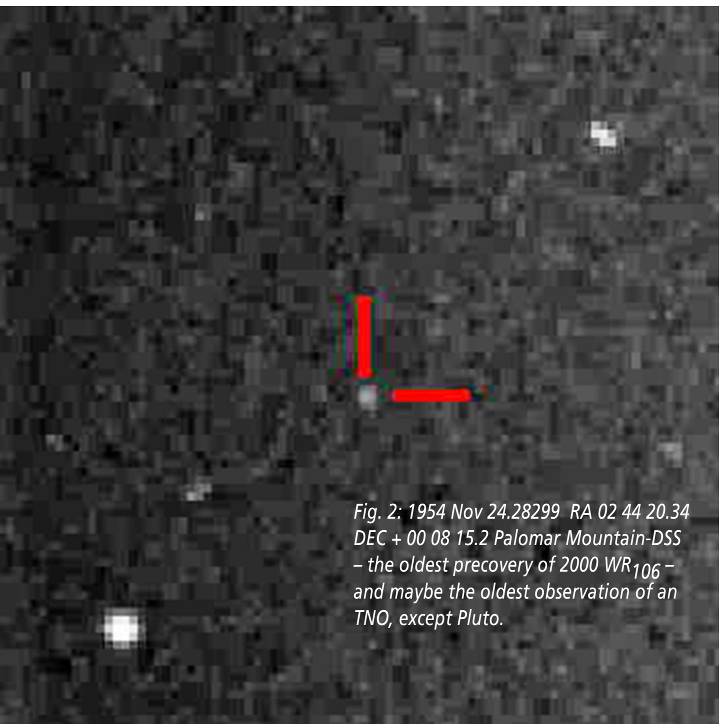

Fig. 2: 1954 Nov 24.28299 RA 02 44 20.34 DEC + 00 08 15.2 Palomar Mountain-DSS – the oldest precovery of 2000 WR_{106} – and maybe the oldest observation of an TNO, except Pluto.

Fig. 4: Varuna with his wife Varunani. Statue made from Basalt, dates back to 8th century CE, discovered in Karnataka. On display at the Prince of Wales museum, Mumbai.
Source: Wikipedia CC BY-SA 4.0

orbit did not fit. During the next three weeks, however, 2000 WR_{106} was detected by the observatories of Mauna Kea (Hawaii), Mt. Hopkins (Arizona) and Kuma Kogen (Japan) [2]. The new assumed circular orbit was good enough to start searching for it in plate archives again. On the search areas of the POSS-plates of 1997 Jan. 10 and 1996 Oct. 10 we found suspicious objects. With the astrometry of these objects, an improved orbit was calculated and another two plates from 1996 Feb. 15 and 1996 Jan. 14 were found. This procedure was repeated again and again until all plates which showed 2000 WR_{106} had been picked up. As a result, this large TNO had observations from 6 oppositions spanning 46 years, with the 1954 Nov. 24 observation is, perhaps, the oldest observation of a TNO other than Pluto. This position of this old observation differed by about 3 degrees from the backward extrapolation of the approximate first orbit.

The numbering

On January 9, 2001, just six weeks after the discovery of 2000 WR_{106}, the Minor Planet Center published a new Minor Planet Circular. In the Editorial Notice [3], the numbering of 2000 WR_{106} was announced. Because of the unusually large transneptunian object (at this time, the diameter was expected to be like Ceres) and the coincidence of this recognition with the Ceres bicentennial, the Minor Planet Center decided to give the »special« number 20000 to this large cubewano object. Another superlative for this object: it has gone from discovery to being eligible for numbering within the shortest time span…

The name

By the rules for asteroid naming, objects in the classical TNO belt are named after creation deities. The name »Varuna« was suggested by M. Sarabhai. [4] Varuna is a vedic deity, the creator and upholder of heaven and earth. He presided over the waters of the heaven and the ocean and was the guardian of immortality of gods and men and the universe and has unlimited knowledge.

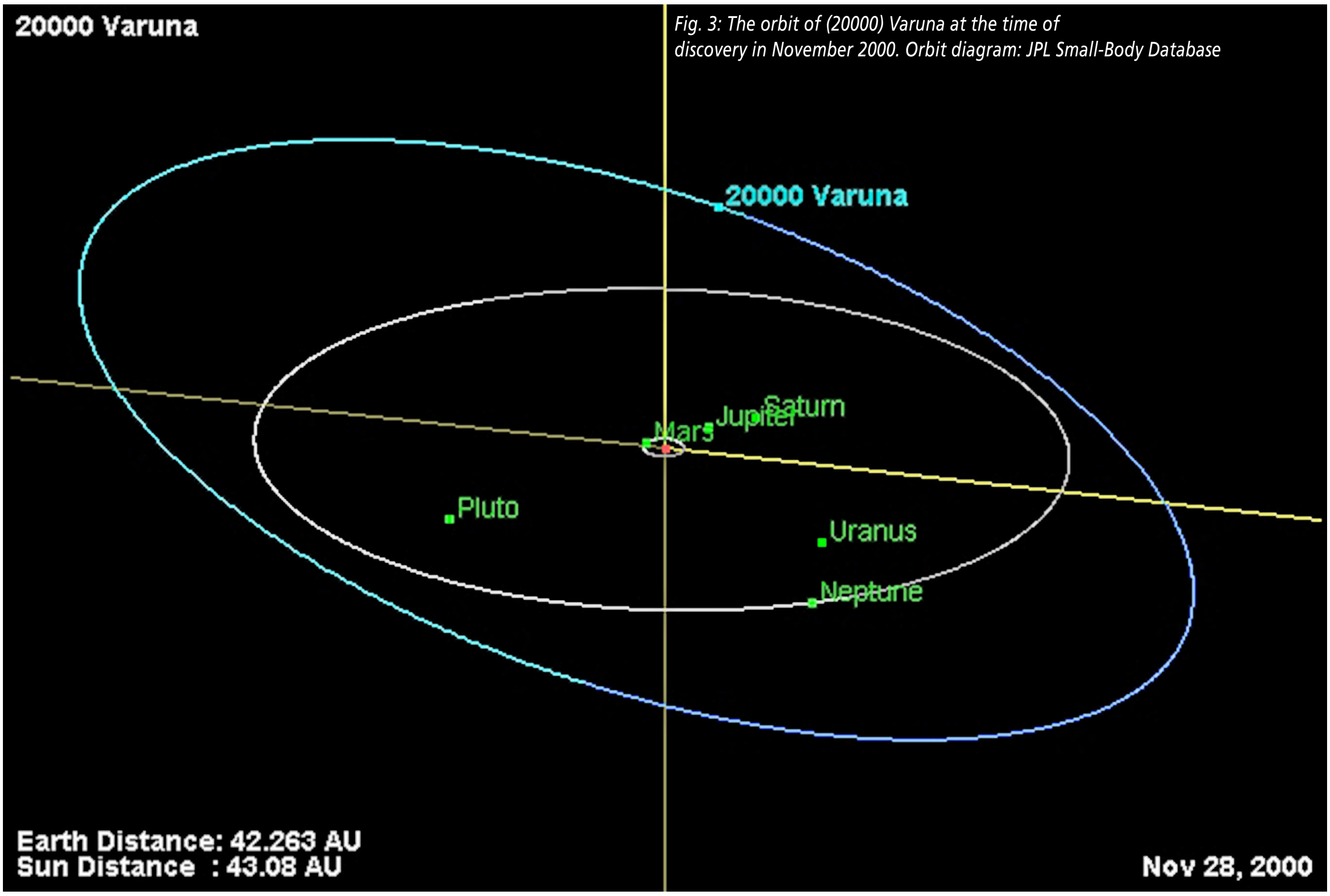

Fig. 3: The orbit of (20000) Varuna at the time of discovery in November 2000. Orbit diagram: JPL Small-Body Database

What we know

Varuna is one of the largest cubewanos , a class named after the asteroid (15760) 1992 QB_1. This asteroid was the first discovered object of this class and similar objects, discovered later, are called, »QB_1-o's«, or »cubewanos«. These objects are classical Kuiper belt objects with low eccentricity and no resonance with Neptune.

Varuna has a near-circular orbit (e=0.050464) with a semi-major axis of 43.123 AU and an inclination of 17.165°. The orbital period is 283.19 years.

The diameter of Varuna is not exactly known. Measurements of the space-based telescopes Spitzer and Herschel gave a range of 500-700 km, ground-based observations suggested a value nearly 1000 km. Only one occultation (2010, February 19) of an 11.1 ^{m} star was successfully observed. In Sao Luis, Brazil, a duration of 52.5 +/- 0.5 sec, corresponding to a chord length of 1003 +/- 9 km was observed, but in a distance of 225 km (Quixada, Brazil) the observation was negative, therefore a significantly elongated shape is required for Varuna. That also fits with the observation of the rotational period of 6.3436 hours with a double-peaked light curve. Given the rapid rotation, rare for such large objects, Varuna is thought to be an elongated spheroid (ratio of axis 2:3). The geometric albedo is 0.127 - a dark, moderately red object.

The surface of Varuna consists of a blend of amorphous silicates (25%), complex organics (35%), amorphous carbon (15%) and water ice (25%). Another possible surface composition containing up to a 10% of methane ice, this is currently disputed. This volatile cannot be primordial, so an event, such as an energetic impact, would be needed to explain this surface feature.

At present, (20000) Varuna does not boast the status of a dwarf planet – but is listed as »highly likely« in the list of Michael E. Brown from Caltech.

[1] Minor Planet Electronic Circular 2000-X02 (2000 Dec. 1)
[2] Minor Planet Electronic Circulars 2000-Y26 / 2000-Y37 (2000 Dec. 21 / 2000 Dec. 24)
[3] Minor Planet Circular 2001 Jan 9 (MPC 41805- 42004)
[4] Minor Planet Circular 2001 Mar 9, (MPC 42217- 42426)
[5] http://adsabs.harvard.edu/abs/2010DPS....42.2311S

Images of this article taken from the Digitized Sky Survey, taken at the Space Telescope Science Institute under U.S. Government grant NAG W-2166. The images of these surveys are based on photographic data obtained using the Oschin Schmidt Telescope on Palomar Mountain and the UK Schmidt Telescope. The plates were processed into the present compressed digital form with the permission of these institutions.

An Extension Cable for the Remote Control of the WATEC-910HX/RC

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Introduction

Occultation observers sometimes use equipment, which was not designed for the use under hard observing conditions (e.g. low temperatures). One example is the well known WATEC-910HX/RC, a camera designed for surveillance. The remote control is connected to the camera with a tiny connector of six very thin wires. It's just a matter of time when a wire will broke. The following report shows a solution for this problem. **Be aware: Any changes of the hardware of the camera will affect the warranty!**

I was aware of the problem with the tiny wires, but… too late!

It was a nightmare of an occultation observation. In December 2016 I had set up my telescope to measure an occultation by (275) Sapientia. First my GPS didn't worked because of broken wires inside the D-SUB 9 connector. Soldering was not possible in time, so I had to use a DCF-Beeper as a backup time source. Finally I was lucky with this backup because the observation was positive! A little bit frustrated I took the equipment back into the house. Then I found one of the small wires at the remote control of the camera WAT-910HX/RC nearly broken. I was aware I had to fix this at once, the next observation session would be in danger. I had heard about the problems with this tiny connector before, but I had put aside. Shame on me.

Repair it and improve it

My decision not only to replace the connector but to improve the cable was made at once.

The original cable has a length of 1.5 meters only. That's too short for working at a notebook for framing and setting the exposure at a table near the telescope. So I would prefer to extend the cable. Because the cable has six wires, I would need a stable connector with at least six wires. The old D-SUB 9 serial connectors are very large but easy to handle and they have 9 pins.

But I had made some bad experiences with soldering broken wires (see my GPS problem) at a D-SUB 9 connector in the night. This time I choose

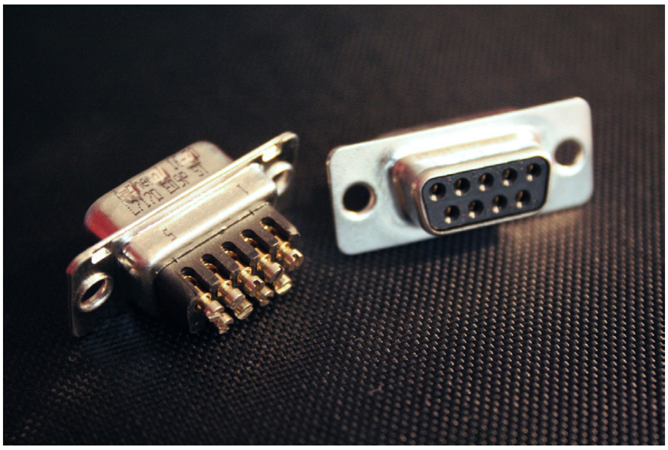

Fig.1 The D-SUB 9 - a classic serial connector with nine pins. The wires are locked in place by tiny screws.

D-SUB 9 connectors which have little screws holding the cables in place. [Fig. 1] They are more expensive, but I guess repairing a cable in the field, where you have no possibility to solder, should be much easier. So I ordered a male and a female connector and a 2-meter D-SUB 9 cable as an extension of the remote cable. This cable is of bright colour and therefore visible under bad light conditions.

Replacing the tiny connector - Where do I get a new one?

I had to spend a whole day for searching at the internet to find out which type of small connector was used at the cable and where to get it. Finally I found the information, that the connector is named JST GHR-06V-S 1.25mm. [Fig.2]

It is used for connections at computer boards. Finally I ordered this connector with six cables (20 cm length) attached already in the U.K. at a company, who sells parts for drones. The cables are named JST GH1.25 at this shop. The package has five of these JST-connectors with cables, so I have spare parts already for the future. The amount for this replacement was 7.50 GBP including shipping to Germany. The delivery was very fast, I got my cables just a few days after ordering. [Fig.3]

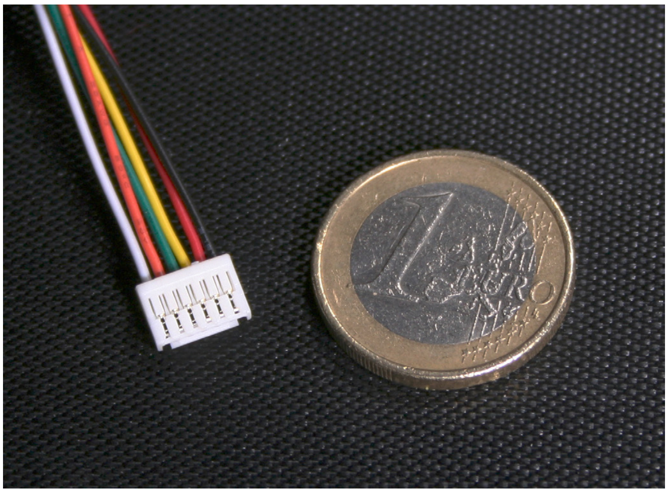

Fig.2 The small "JST GH1.25" connector, which is used at the camera to connect the remote. Please note: this image shows the replacement with different colours of the wires compared to the original connector, which comes with the Watec.

Fig.3 The package of five connectors with wires I have got from U.K. One is already in use. The wires are 20 cm long.

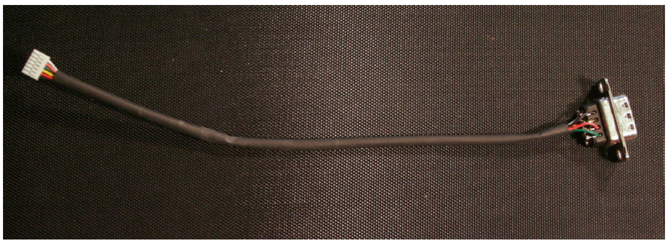

Fig.4 The male D-SUB 9 without housing is connected to the replacement cable. A piece of heat shrinkable tubing protects the small wires.

Connector-Replacement WATEC-910HX/RC

Original connector (pins facing me, silver contacts visible)
from left: **green...blue...yellow...white...red...black**

NEW connector (pins facing me, silver contacts visible)
from left: **black...red...yellow...green...orange...white**

D-SUB connector

Pin	Camera	Remote
1	white	black
2	orange	red
3	yellow	yellow
4	-	-
5	-	-
6	green	white
7	red	blue
8	-	-
9	black	green

Table 1 My notes of the wiring of the new connectors for reference in the future.

Making the remote extension cable

Advice:
When making the cable you must be aware that the colours of the wires of the replacement differ from the colours of the original Watec-cable! Note the colours carefully and store it as a reference for the future!

First I added a heat shrinkable tubing or rubber grommet to protect the thin cables. Then I mounted the male connector (female connector would be possible too - it's your choice) at the camera side. [Fig.4] I noted which cable (colour) was connected to which pin. That's your choice too. But take care that the the pins of the connector at the remote side are corresponding to the choices you have made. Double check your notes of the colours of the wires which you have written down before to avoid any false connection. [Table 1]
Then I mounted the female connector at the original 1.5 meter remote cable. Finally I marked the connectors with some coloured markings. So I will see under low light conditions which side of the extension goes to the camera side and which one to the remote side at once.

Strain relief for protection

A extended cable with more weight using with this small connector at the camera – you can expect the next broken wire very soon.
Therefore we have to take care of making a strain relief at the camera. So I used a 1/4 inch screw and two washers. The cable is squeezed between the washers and there are no forces at the tiny connector

Fig.5 The camera with the replacement attached. On top the strain relief with two washers and an 1/4" screw. The D-SUB 9 has a coloured marking.

Fig.6 Camera with cable replacement, the extension D-SUB cable and the original remote cable with attached D-SUB connector. The connectors are marked for handling under bad light conditions.

anymore. [Fig.5] Additionally the extension cable is wrap around of one of the handles of the telescope. So the weight of the cable will not drag at the camera.

Using the new cable

It's now possible to use the remote with the 2-meter-D-SUB cable. The cable length is now 3.5 meters in all. That's enough for working close to the telescope. If a longer extension is needed in the future, the 2-meter-D-SUB cable can be replaced with a longer one. You can even use the remote with no extension at all. But I think I will never do this. The original cable of 1.5 meters is really to short. Now I'm ready to start measuring occultations again. [Fig.6]

References:

Discussion about the camera and the tiny wires:
https://stargazerslounge.com/topic/247504-watec-910hx-first-impres-sions-and-caveat/

Source for the replacement cables:
https://www.unmannedtechshop.co.uk/

Data sheet of JST connector:
http://www.jst-mfg.com/product/pdf/eng/eGH.pdf

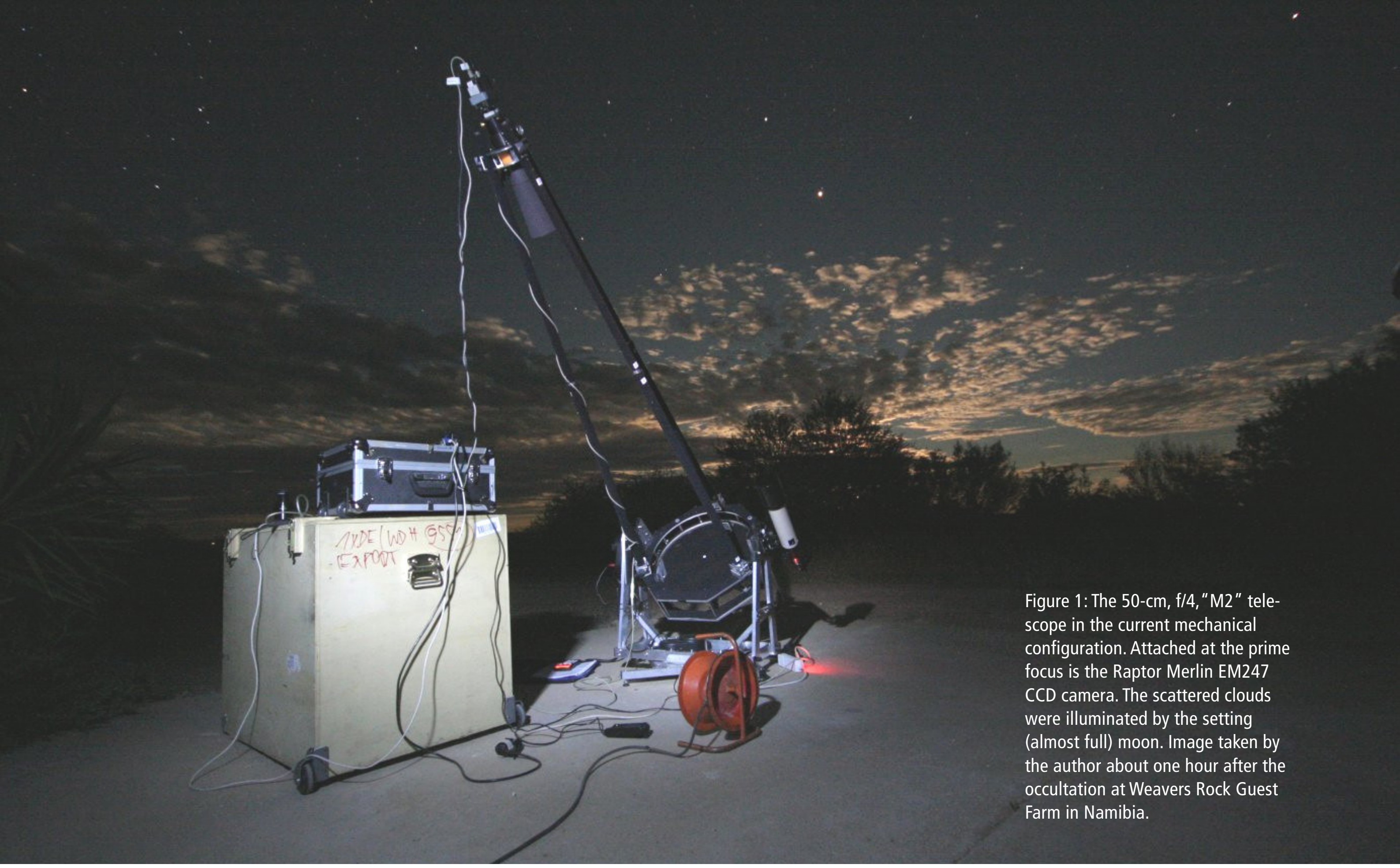

Figure 1: The 50-cm, f/4, "M2" telescope in the current mechanical configuration. Attached at the prime focus is the Raptor Merlin EM247 CCD camera. The scattered clouds were illuminated by the setting (almost full) moon. Image taken by the author about one hour after the occultation at Weavers Rock Guest Farm in Namibia.

Report about the 2017 Apr 09 Chariklo Occultation Observation

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Abstract: A successful occultation observation of a 14 Gmag star by the Centaur (10199) Chariklo on 2017 Apr 09 using the IOTA/ES 50-cm "M2" portable Alt-Az telescope in Namibia is reported.

In the last JOA issue (2017, No. 1) I wrote about the Centaur (10199) Chariklo within the "Beyond Jupiter" series. Despite the fact that Centaurs are very interesting objects in general, Chariklo is special as it is currently the smallest object (diameter about 260 km) which is known to have rings. This ring system was detected during an occultation in June 2013.

For the year 2017 at least two occultations are predicted to be visible from Namibia and South Africa, the first one on April 09 (02:13 UT), the second one on June 22 (21:21 UT). Both events were selected to be observed from Namibia within the well known pro-am collaboration between Paris-Meudon Observatory (Lucky Star project) and amateur astronomers from Namibia, IOTA (/ES) and IAS (International Amateur Observatory).

IOTA/ES decided to use a portable 50-cm f/4 telescope for both occultations, i.e. to ship it from Germany to Namibia in April and to leave it there until the June 22 occultation. This would also be a good test of sending this kind of cargo into the world. I traveled to Namibia in April and used this telescope for a successful observation of the occultation by Chariklo which is reported here. At the time of writing I am preparing for the second trip to Namibia for the June 22 event.

A couple of years ago IOTA/ES recognized the need of a mid-size, but still portable telescope for occultation astronomy of TNO's, planetary moons etc. which is able to capture occultations of stars down to about 17-18 mag. In 2013 a second hand 20-inch Dobson (Alt-Az) telescope was bought with the plan to rebuild it for this purpose. This telescope (Fig. 1) and its "history" was recently described at ESOP 35 last year in Guildford, UK (Guhl, 2016). During an inauguration party which has been held at the Archenold Observatory in Berlin on the 8th of October 2016 the telescope was named "M2", honoring the construction efforts by Michael Busse and Michael Dohrmann. The first real observation with this instrument has been the successful observation of the occultation by Pluto on 2016 July 19 by K. Guhl and M. Dohrmann. Based on this first experiences the telescope was further improved and modified.

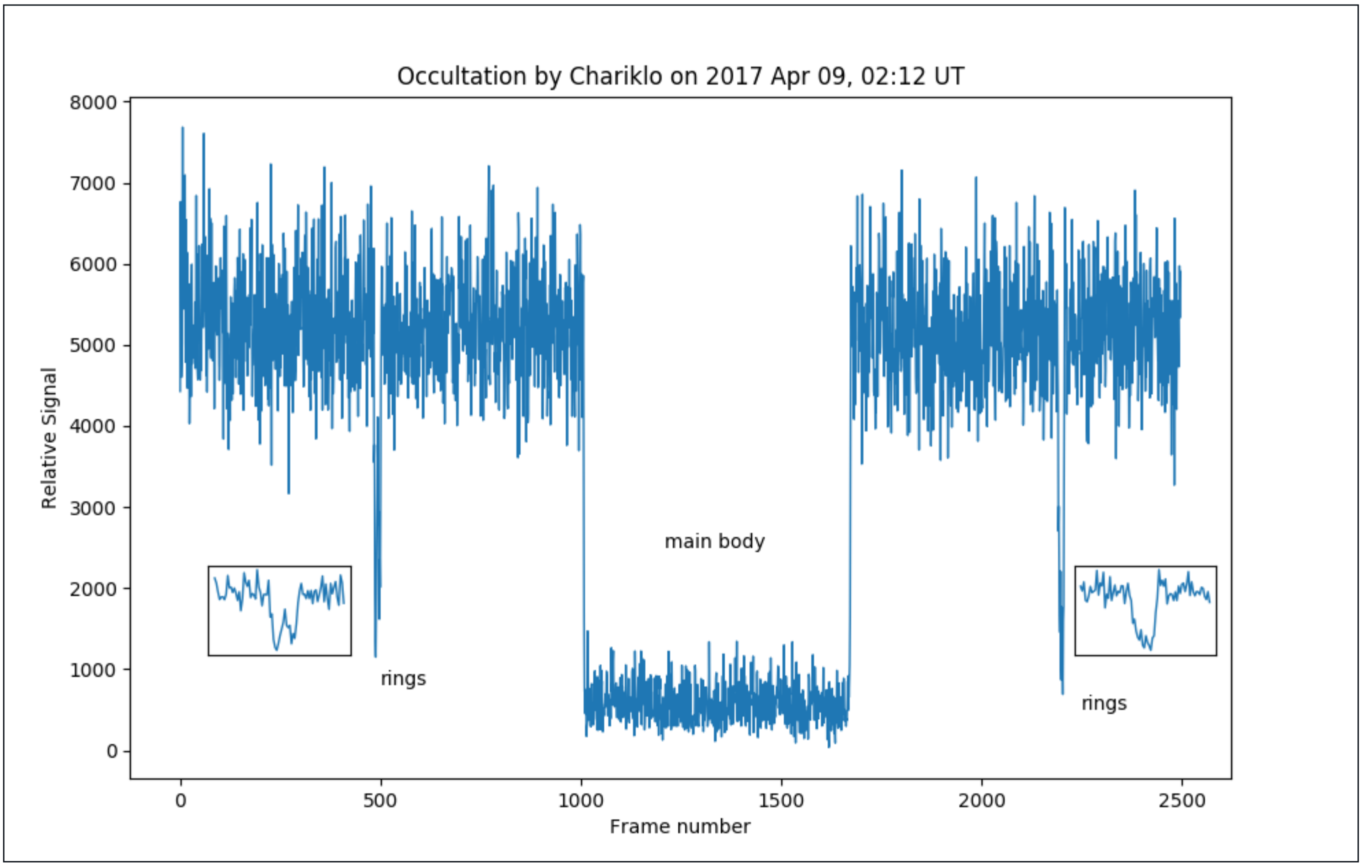

Figure 2: Lightcurve of the occultation by the Chariklo system, taken with the 50-cm f/4 "M2" telescope at Weavers Rock Guest Farm (Namibia) at a data rate of about 12.5 Hz. The observed main body occultation duration was 54.9 sec, which corresponds to a chord length of 263.5 km. Observer: Mike Kretlow.

In March 2017, after we had decided to ship the M2 telescope to Namibia for the Chariklo occultation campaign, I went to Berlin where Konrad Guhl and Michael Dohrmann at the Archenold Observatory were working on further modifications of the telescope and preparing it for shipping. I became familiar with the instrument and its assembly and disassembly. We did final tests and identified remaining issues to be solved by them before sending the telescope to Namibia. All together the weight of the instrument including the wooden transport box is approximately 60 kg. Mid of March the box was handed over to an air cargo company at Berlin Tegel airport.

I arrived at Windhoek airport on April 4th early in the morning and after releasing the telescope from customs (which required hours because of missing documents) the telescope was transported by car to the planned observing site (Weavers Rock Guest Farm near Otjiwarongo). The following nights were used for training, tests, solving some minor issues and to find the best camera setup. Due to the rather big aperture of the telescope and the good performance of the Raptor Merlin EM247 CCD camera, a pretty good SNR could be achieved even with the finally chosen 80 ms exposure time (~12.5 fps). As Chariklo's shadow speed was 4.8 km/s this time resolution corresponds to about 0.4 km spatial resolution for an observer on the center line.

About 36 hours before the occultation, bad weather came in from the North (Angola) and essentially all stations were (potentially) affected. The day before the event was dominated by (broken) clouds and occasional rain showers. After sunset on the occultation night my station was completely clouded out until about one hour before the event, when the first larger cloud gaps appeared near the target field. Since the Goto functionality of the telescope didn't work I had to find the field manually via star hopping and because I trained this the nights before this paid off, as I managed to set up everything in time, despite some technical problems I even had to fix. I started recording 10 minutes ahead the nominal occultation time. The complete occultation was observable without any disturbing clouds, though parts of the sky were still clouded (shielding a little bit the moon). Figure 2 shows the preliminary lightcurve of the occultation. The next day started overcast and with raining in the afternoon. All in all we were lucky in view of this weather situation. My colleague Jean-Luc Dauvergne was also able to record the occultation (main body and ring system) with a 12" telescope about 70 km north of my station, but unfortunately some other stations were clouded out.

I would like to thank Paris-Meudon Observatory for the financial support (Lucky Star EU project), IOTA/ES for providing the instrument and Jean-Luc Dauvergne (Ciel & Espace) for the great team work in Namibia.

Further reading

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Journal for
Occultation Astronomy

Occultation of UCAC4 345-180315 by Pluto on the 19th of July 2016

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The following contributors have been essential for this work. Without these persons and organisations it would not have possible to achieve these results. They either contributed to the astrometry beforehand, to the observation itself or further data analysis. This report is based on 20 stations successfully gathering data.

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The light curves in this report mostly cover the amateur community who took part in this amazing event. More data from other organizations do exist and are under analysis from different teams. All together this was a true PRO-AM cooperation which showed the importance of such campaigns.

Abstract

The 14th mag star UCAC4 345-180315 was occulted by Pluto on the evening of the 19th of July, 2016. The event could be observed from large parts of Europe, middle east and northern Africa as well. A campaign had been organized 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 predictions were largely done by the RIO team and Bruno Sicardy's team. A fainter star was occulted by Pluto 5 days before (14th of 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 of the New Horizons team the occultation track for the 19th could be determined by this with very high precision (pre- versus post occultation calculation only differed in less than 100 km).
Because of good weather conditions for the event in large parts of Europe, observations of about 30 stations could be recorded and analyzed. This report will describe the observations of about 20 stations and their lightcurve analysis. In a further report the atmospheric properties in the year after the New Horizons flyby on will be discussed.

Introduction

Because a space probe flyby can only determine conditions in the atmosphere for one single time point, a continuous monitoring of the status of the atmosphere of Pluto using stellar occultations is necessary. Occultation astronomy is the only precise way to evaluate these data.

Pluto's atmosphere is undergoing a large meteorological experiment in the next decades. Due to its elliptical orbit with large excentricity (0.2488) the solar distance of Pluto has increased since its perihelion in 1988. This leads to a decrease in solar flux down to 80% up to now and down to 36% for the next aphelion in the year 2114. The variation of Pluto's atmosphere due to the decrease in solar irradiation can be observed with even small equipment by occultation astronomy.

The changes in Pluto's atmosphere over the last 30 years since its perihelion had already been followed up by occultations. The first successful occultation observation ever was in 1988 by Hubbard et.al. (1988). In 2001, surprisingly, instead of the predicted decrease in atmospheric pressure an increase of atmospheric pressure has been observed (Sicardy et.al. (2001), Elliot et.al. (2001). This may be caused by seasonal effects, turning parts of Pluto into light, which have been in darkness for a long time. This could cause for sufficient sublimation of nitrogen to resupply the atmosphere and compensate for the loss of solar radiation. How long this will happen is still undetermined and scientists wait for changes in pressure to be observed.

One of the main problems in data gathering are the many different observation techniques, cameras and telescopes used. Telescopes of sizes from 0.2 to 1.2m took part. Cameras using analogue video had to compared with fully digital systems. Using conversion to single FITS files was used to unify the results of analogue and digital cameras. Using GPS time inserters or internet time protocols had delivered high precision timing in the past and had been used for this event too.

Because at the first predictions (like figure 1) it was assumed, that the central line of the occultation would path across main parts of Europe. Because of the high density of astronomical observatories in this area, it would present an ideal situation to observe in detail the Central Flash. This would give a very detailed insight in the structure of Pluto's atmosphere, such as a possible deviation of a spherical structure.

The NASA space mission New Horizons (NH) has sent an enormous amount of data and images back to earth. The layers of the atmosphere could be seen clearly and the occultation experiment delivered details of the atmosphere. The structure of the atmosphere delivered by NH could be compared with earlier results of occultation astronomy from earth and an astonishing agreement could be found. But the NH data only delivered one single time point and never in the next 20 or 30 years any more detailed data like from a space probe will be sent to earth.

Circumstances and preparations

The occultation of UCAC4 345-180315 by Pluto for many parts of Europe was one of the most important occultation events in 2016. The occultation will not only allow to improve Pluto's orbit, but will also allow to follow the development of its thin atmosphere, when Pluto's distance to the sun is increasing with the years. In the last two years Pluto's atmosphere has further increased its density, as recently published by Sicardy et.al. (2016).

Pluto occults a **14mag** star UCAC4 345-180315 visible from many parts of Europe on the evening of the 19^{th} of July 2016 around 20h 51min UTC. Table 1 gives position (UCAC4) and photometric details of the occultations on the 19th and on the 14th as well. The occultation on the 14th of July (the "pathfinder" occultation) was used to improve the astrometry of Pluto. From older occultations it is known, that Pluto's atmosphere is nearly spherical shaped. Therefore the CF is expected to be very small and sharp. For measurement of the Central Flash (CF) an excellent prediction of the occultation track is necessary. A good opportunity to determine the exact occultation track was the occultation of UCAC4 345-180583 on the 14th of July just 5 days before the main event. As can be seen in figure 2 this "pathfinder" occultation was also visible from Europe. The star was much fainter, only 16m1 in V. This gives a light drop of only about 10% for the event, but it was enough to be observed from a few stations. This was specially important, because the astrometry of Pluto is always hampered by the light of its moon Charon. Table 2 gives an overview for all stations where lightcurves have been extracted for the main occultation.

A second great improvement came from the release of the position of the target star by the GAIA team well ahead of the publication of the GAIA DR1 catalog. For this action the occultation community had to be very thankful to the GAIA mission team. Together with a new Pluto ephemeris from the New Horizons team a new occultation track could be evaluated, showing a large southern shift (figure 3). The new central line passed across northern Africa and missed central Europe.

But still, the occultation of the main body passed one of the most highly "telescope populated" areas in the world with countless instruments in the 16inch and up class. Such kind of instruments are perfectly suited for this kind of observation, but even smaller instruments can deliver competitive results.

Technique to derive lightcurves

All lightcurves shown in this report have been derived from original images, originally taken as single FITS images or derived from AVI sequential image files. Image processing was done under LINUX operating system (http://www.opensuse.org).

AVI files were segmented into single FITS images by using the "ffmpeg" tool (http://ffmpeg.org) followed by the CONVERT utility from IMAGEMAGIKK (http://www.imagemagikk.org). This results in a sequence of FITS images similar to directly recorded images. However, these AVI-extracted images have only 8 Bit of resolution and their linearity can not be guaranteed, because of the mostly unknown properties of the digitizers used to convert the analog stream to AVI. For those extracted FITS files the timing was calculated based on the visual information in the image itself. The time of the first image and of the last were used to get an interpolated timing scheme for each image in the sequence. Textual information given by the observers in separate statements were used to adjust the timing as precise as possible. These timings were controlled by visual inspection for some images in the stream, to guarantee a linear time increase over the whole sequence.

FITS images were flat-fielded and dark frames were subtracted where available. If available timing keywords of the FITS files were used to extract the time of exposure and were converted to UTC seconds of the day where applicable. For the timing of the images the various keywords in the FITS files were evaluated. If given, separate written information of the observers themselves was used to further adjust timings in the images.

For each series of FITS images from an observing station, an analysis was done using procedures written for MIDAS (http://www.eso.org/sci/software/esomidas/), the image analysis program developed by the European Southern observatory (ESO), Warmels (1991). A short overview of the procedure is described in the following:

For most observations, telescopes with a diameter of 20 to 40 cm had been used. These telescopes have not always been perfectly guided. Therefore the stellar images could move around in the image quite a lot. A proper procedure had to be found to compensate this stellar movement.

For each image sequence, a bright star, which had to be visible in all images of the sequence, is selected as a reference star (RStar). In the first image of the sequence, the approximate pixel coordinates of RStar in the image using a centroid were evaluated. In the subsequent images, it is assumed that the position of RStar is not changed more than 50 pixels in x and y direction due to sudden guiding errors. A centroid was determined in a large window around the old position, giving an approximate position of RStar in the new image. This approx. position of RStar was refined by setting a smaller window and calculating the centroid again. This leads to the determination of the image coordinates of RStar in each frame even if the star position in the image has changed from one image to the next.

For a set of up to six other stars, including the target object itself, intensities were determined. An inner ring for stellar intensity, a nomansland and an outer ring for background determination were used in classical aperture photometry. The position of the stars were calculated by defining a centroid, each time. Only, if the star was too faint, a fixed distance in x and y with reference to the RStar were used as center of the rings in aperture photometry. In some cases the target star was too faint during its occultation to be clearly defined. Here also the method of fixed distances was used. This procedure leads to a table of intensities for RStar and the other stellar objects choosen. For each image in the sequence, the image number, a timing information and the intensities of the stars are written in a text file for further evaluation using DATAPLOT software of the NIST (National Institute for Standards and Technology (US Department of Commerce, USA) (http://www.itl.nist.gov/div898/software/dataplot/). For observation stations, where less than 6 stars besides RStar are available the protocol was restricted to the number of star available in the particular sequence.

Analysing the result file, a first overview of the quality could be done by visual inspection. To further adjust the size of the rings of aperture photometry and other parameters as well with respect to the image quality and stray light in the telescope etc., a part of the lightcurve well outside the time period where the occultation happened was used for referencing. For this part of the lightcurve it is assumed, that the intensity of light of the target does not change with time other than from imaging problems and atmospheric szintillations and flickering or unproper aperture setting for photometry. The standard deviation of the intensity of the target with respect to time was used for optimization. This process was done visually and parameters were changed by hand accordingly to minimize the relative standard deviation. For each observation station, the parameters had slightly to be varied. If perhaps the telescope of a sequence was not focused properly, larger apertures had to be used for lightcurve extraction. The same was the case for larger positional scintillation of the stars due to atmospheric turbulence.

A detailed description or parameters for each observing station are beyond the scope of this report.

The target star UCAC4 345-180315 with its approximate magnitude of 13m5 in the R Band is close to the star UCAC4-345-180294 with 12m7. This star was taken as intensity reference star for nearly all sequences.

The RStar was for most image sequences the star UCAC4-345-180307 with a magnitude of 10m3. In case of the 1.2m telescope at Trebur only the star UCAC4-345-180294 was visible in the image and was therefore used as Rstar and for intensity referencing as well. All lightcurves in figures 5 to 8 are normalized with respect to the star UCAC4-345-180294

It can be seen, that the variations in the quality of LCs are large. One of the reasons can be the near full moon (age 15.4 days), which was in a distance of 10 degrees to the target star during the occultation. It produces an enormous amount of light scatter in the atmosphere and in the tube of the instruments as well. The latter of course is depending on the optical type and construction of the instrument. There have been no reports, if any shades have been used for observing or other precautions. A further problem was the low altitude of Pluto for many stations, ranging from only 13.8 to 29.7 degrees (Table 2). This caused a lot of atmospheric disturbances preferentially for the northern stations.

Comparison of different stations

For the observations telescopes from 20cm diameter to 1.2m were used. This implies a large range of lightcurves with different resolutions and noise. Even more, exposure times ranging from 10 seconds down to .16 seconds were used. Therefore it has been tried, to compare the quality of LCs with each other. The total number of photons in each image of the sequences is proportional to the telescope area multiplied with the exposure time. Therefore, if the lightcurve of each station is compared with other stations, intensities from individual images are added up to a point, where the total number of photons is always the same. To give an example, an exposure time of 1 second on a 20 cm diameter instrument should give the same number of photons as an exposure time 0.25 sec for a 40cm instrument, neglecting different obstruction factors, reflectivities etc.. If however, the 40cm telescope uses an exposure time of 1 second, the number of photons per data point is 4 times higher than in the case of the 20cm telescope and 1 second exosure time there. To come to equal photon number per datapoint, 4 data points of the 20cm telescopes have to be added to give equal photon numbers. This process had been done for 5 typical stations,for Suwalki (20cm, 2.0 sec), Neutraubling (27 cm, 1.28 sec), Emberger Alm (34 cm, 0.16 sec), TAC Calern (40 cm, 0.16 sec) and for Trebur (120 cm, 0.35sec). The resulting lightcurves are shown in figure 9.

After this procedure, the lightcurves are more comparable, but still lightcurves such as for Trebur (figure 9 e) show more noise than other lightcurves.

Final results of this report

In this report lightcurves from 20 observing stations have been analyzed. The post-occultation astrometry, derived from the observed light curves was in perfect agreement with the pre-occultation prediction. The knowledge of the GAIA position of the target star together with the Pluto astrometry from the "pathfinder" occultation 5 days before was a perfect prediction scheme. What can be seen so far is, that Pluto's atmosphere still has not collapsed and did not undergo big changes in the year since 2016. A more detailed analysis will follow. In terms of information of observers this campaign had shown, that in central Europe it is possible to motivate very different observers and observatories to take part in a true multinational observation campaign for professional and amateur observers.
A more detailed analysis of observing techniques, quality of the lightcurves and detailed atmospheric analysis has still to be done and will be reported later.

Acknowledgements
The work leading to this results has received funding from the European Research Council under the European Community's H2020 2014-2020 ERC grant Agreement n°669416 "Lucky Star"

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http://www.itl.nist.gov/div898/software/dataplot/
http://www.eso.org/sci/software/esomidas/
http://ffmpeg.org/
http://www.imagemagick.org

Legends

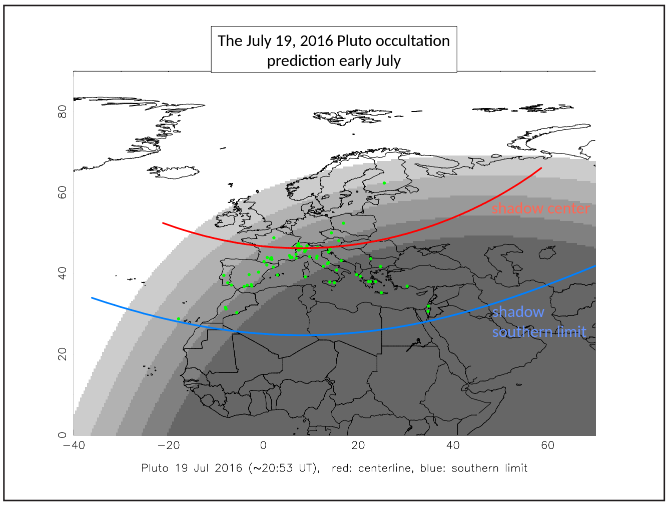


Figure 1
Pre-occultation prediction for the event on the 19th of July at the beginning of July. Without correction by the pathfinder occultation or by GAIA position. Prediction and graphics by the RIO Team and Bruno Sicardy's group.

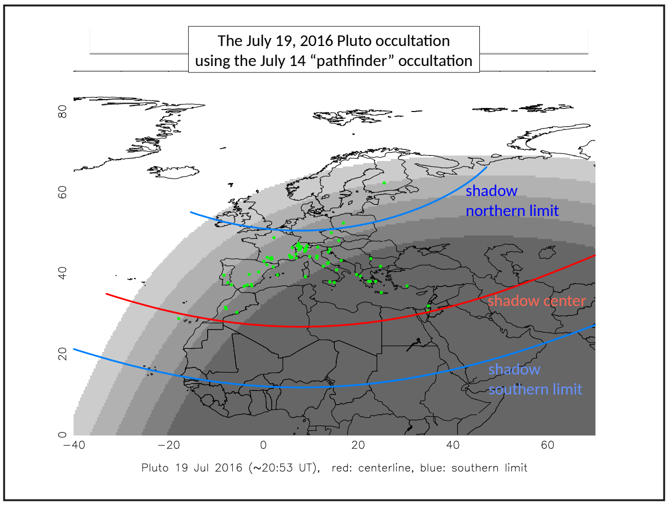


Figure 2
Pre-occultation prediction for 19th of July using the results of the "Path-finder" occultation on the 14th of June. Prediction and graphics by the RIO Team and Bruno Sicardy's group.

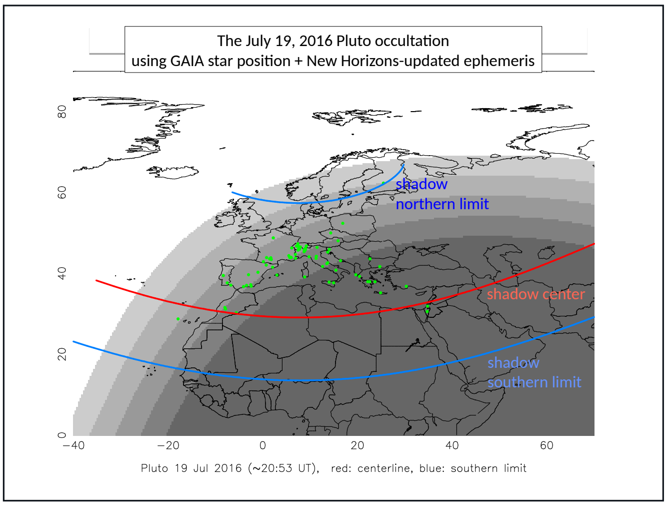


Figure 3
Pre-occultation prediction for 19th of July using the GAIA position and a new ephemeris from the New Horizons mission. Prediction and graphics by the RIO Team and Bruno Sicardy's group.

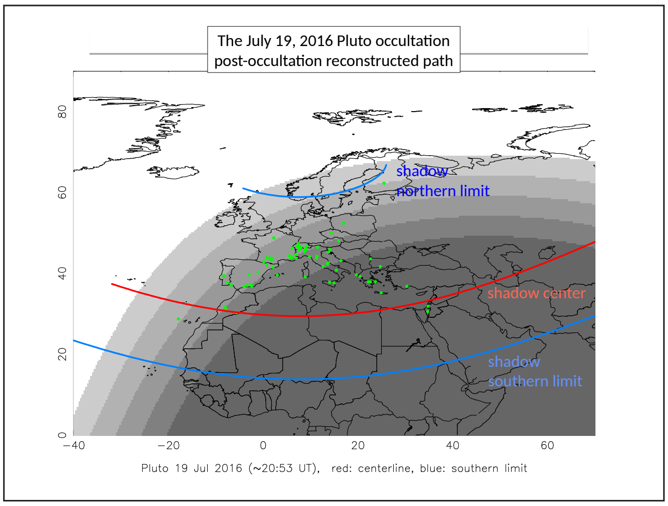


Figure 4
Post-occultation track from the 19th of July. Calculation and graphics by Bruno Sicardy's group.

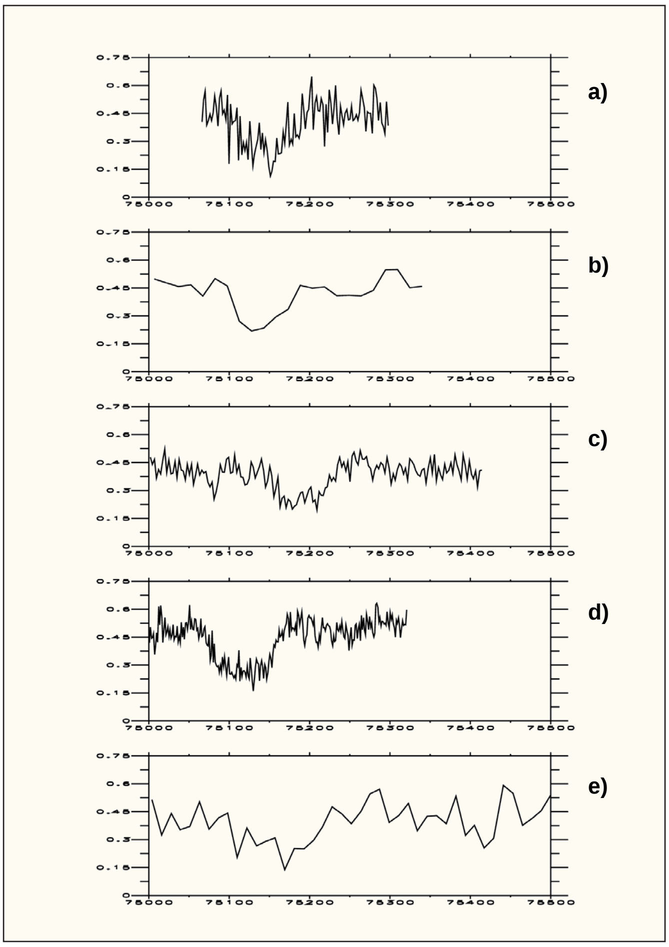


Figure 5
Derived lightcurves from stations with telescope sizes between 20 and 30 cm diameter. Time range of recording for all stations from 75000 to 75500 UTC seconds of the 19th of July, 2016. a) Suwaliki, 20 cm; b) Nova Iwiczna, 20 cm; c) Eppstein, 25 cm; d) Neutraubling, 27 cm; e) Stallhofen, 27 cm

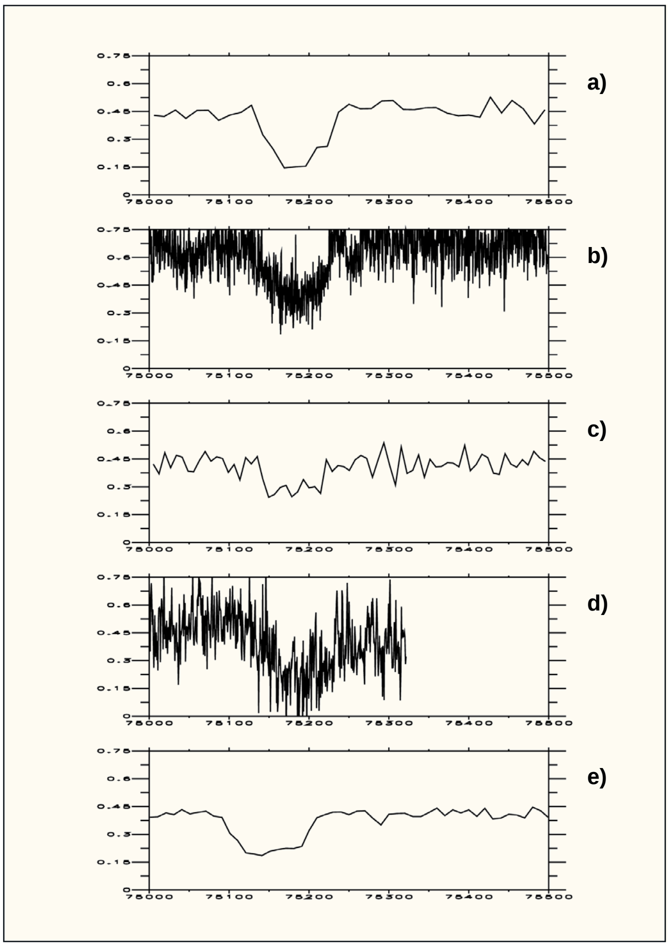


Figure 6
Derived lightcurves from stations with telescope sizes between 30 and 42 cm diameter. Time range of recording for all stations from 75000 to 75500 UTC seconds of the 19th of July, 2016. a) Astron. Obs. Siena 30 cm; b) Otto, 34 cm; c) Kaufering, 36 cm; d) Sternwarte Stuttgart, 40 cm; e) Ellinogermaniki Obs., Pallini, 40 cm.

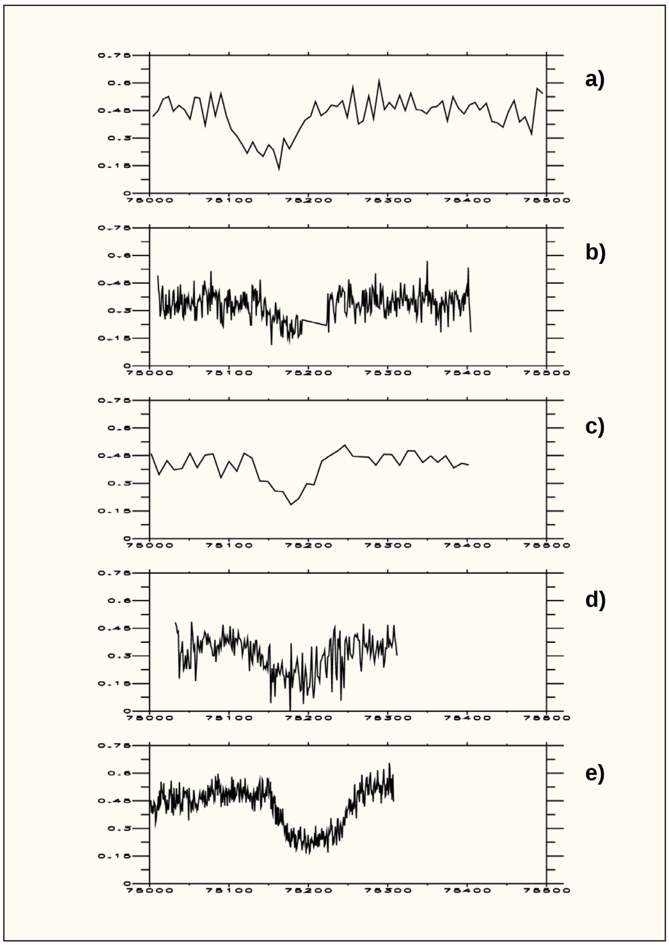


Figure 7 ▲
Derived lightcurves from stations with telescope sizes between 30 and 42 cm diameter. Time range of recording for all stations from 75000 to 75500 UTC seconds of the 19th of July, 2016. a) Univ. Athen, 40 cm; b) Hampf, DLR, 43 cm; c) Munich, DM, 40 cm; d) Hoyerswerda, 40 cm; e) TAC Calern, 40 cm

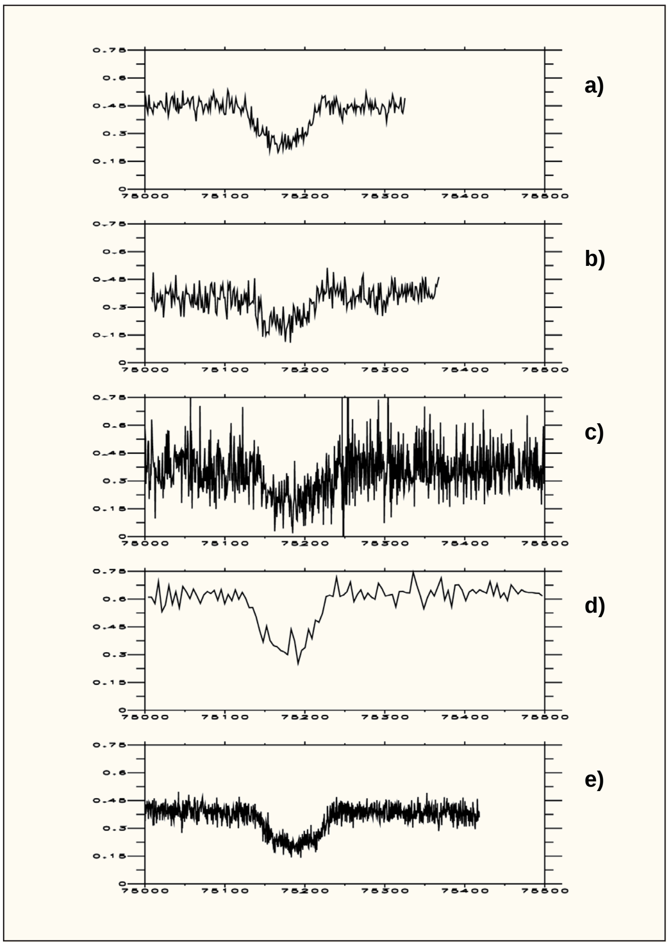


Figure 8 ▲
Derived lightcurves from stations with telescope sizes larger than 42 cm. Time range of recording for all stations from 75000 to 75500 UTC seconds of the 19th of July, 2016. a) Teplice, 43 cm; b) Berlin ASTW, 50 cm; c) Plose mobile M2, 50 cm; d) Munich VSW, 80 cm; e) Trebur T1T, 120cm

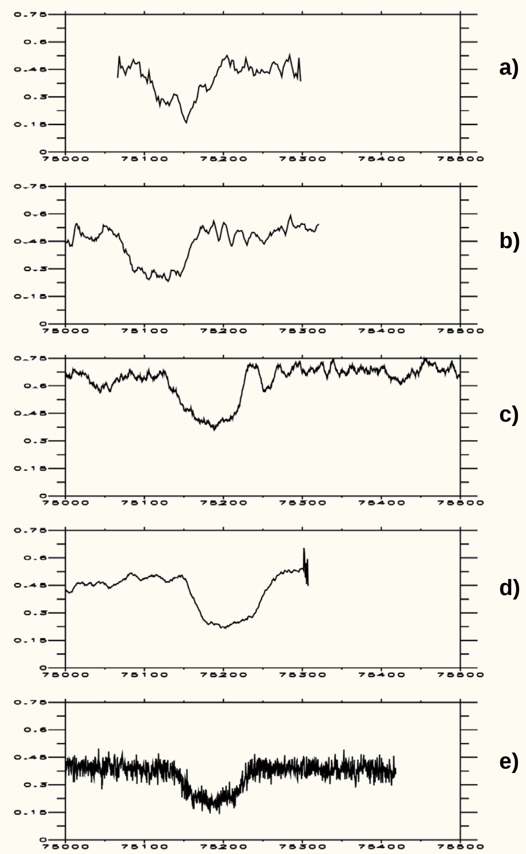


Figure 9 ▲
Selected lightcurves from
a) Suwalki (20 cm diam.),
b) Neutraubling (27 cm diam.),
c) Emberger Alm (34 cm diam.),
d) TAC Calern (40 cm diam.) and
e) Trebur (120 cm diam.).
For comparison the intensities for each data point are averaged according to telescope diameter and exposure time to approximately give the same number of photons per data point.

```
13/14 JULY 2016 "Pathfinder occultaton"
Target  UCAC4 345-180583

Coordinates:(J2000)
 19h 07m 58.08s
-21d 08' 52.5"

Magnitudes:
----------------------------
Object        V      R      I
----------------------------
Star       15.7   15.4   15.2
Pluto      14.6   14.1   13.7
Star+Pluto 14.3   13.8   13.5
drop (mag)  0.3    0.3    0.2
----------------------------

19/20 JULY 2016
Target: UCAC4 345-180315

Coordinates:(J2000)
 19h 07m 22.12s
-21d 10' 28.4"

Magnitudes:
----------------------------
Object        V      R      I
----------------------------
Star       14.1   13.5   12.9
Pluto      14.6   14.1   13.7
Star+Pluto 13.6   13.0   12.5
drop (mag)  1.0    1.1    1.2
---------------------------
```

Table 1 ▲
Table 1 Positional and photometric data for the two stars occulted on the14th and 19th of July

Table 2 ▶
Station data for all 20 stations where lightcurves are shown in this report. The station name gives the nearest City and/or an abbreviation of the station's institution. Next rows give the latitude and longitude of the telescope position (GPS WGS84 position). Followed by the telescope diameter in cm, exposure time in seconds of each image of the image sequence. The last column shows the elevation of Pluto at the time of occultation.

Station	LAT [deg]	LONG [deg]	diameter [cm]	expotime [sec]	PL.elev. {deg]
Suwalki	54,07847	22,92472	20	2,00	14,0
Berlin ASTW	52,48681	13,47522	50	1,28	13,8
Nowa Iwiczna	52,09656	20,99928	20	15,00	15,6
Teplice	50,63833	13,84675	43	0,64	15,6
Eppstein	50,13817	8,36400	25	2,56	14,6
Trebur, T1T	49,92541	8,41129	120	0,35	14,8
Neutraubling	48,98978	12,21592	27	1,28	16,7
Sternwarte Stuttgart	48,78250	9,19642	40	0,64	16,1
Stuttgart DLR	48,78250	9,19642	43	1,00	16,1
München, DM	48,12961	11,58369	40	10,00	17,3
München, VSW	48,12194	11,60722	80	3,00	17,3
Hoyerswerda	48,12194	11,60722	41	1,28	17,3
Kaufering	48,08972	10,84917	36	3,00	17,1
Stallhofen	47,07036	15,24208	27	10,00	19,2
Emberger Alm	46,77461	13,15536	34	0,16	19,0
Plose, mobile M2	46,68317	11,71114	50	0,25	18,7
TAC Calern	43,75222	6,92389	40	0,16	19,7
Astro. Obs. Siena	43,31250	11,33667	30	8,00	21,6
Ell. Obs.Pallini	37,99778	23,89333	40	7,00	29,7
Univ. Athen	37,96667	23,71667	40	2,00	29,7

ESOP XXXVI

36th European Symposium
on Occultation Projects (ESOP)
Freiberg, Germany,
September 15th-19th 2017

We are pleased to invite all interested parties to Freiberg, Germany for the 36th installment of the European Symposium on Occultation Projects. IOTA/ESs annual conference will, as always, include talks and lectures as well as interesting excursions.

Hosting town this time is Freiberg (German for: free mountain), Germany's oldest mining town. Founded in the 12th century in order to exploit silver deposits, the town is closely associated with mining and minerals.

Not only is the largest mineral collection on display at the castle in the heart of the historic old town, Freiberg is also home to the technical university Bergakademie, where two elements of the periodic table were discovered (indium and germanium). The Bergakademie is the oldest university of mining and metallurgy in the world, and educated polymaths such as M. Lomonossow and A. Humboldt.

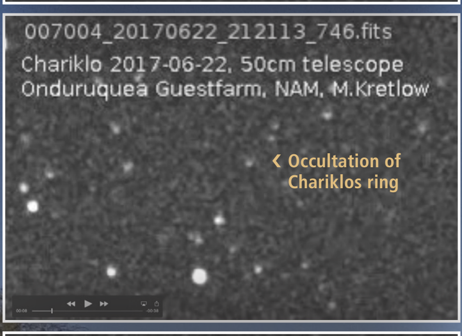
In keeping with ESOP tradition, post conference excursions will be offered.

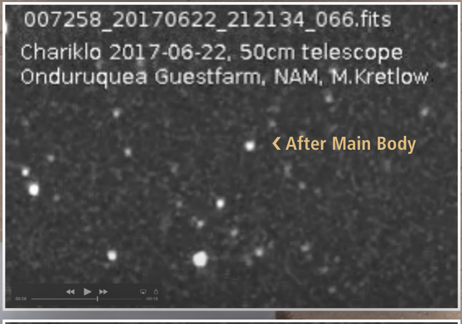
View of the towers of St. Peter's Church (Petrikirche)

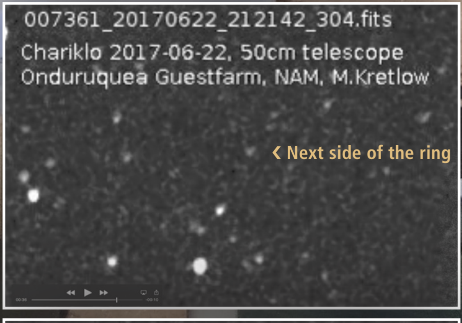
Brief communication on the 2017 June 22 Chariklo Occultation Observation

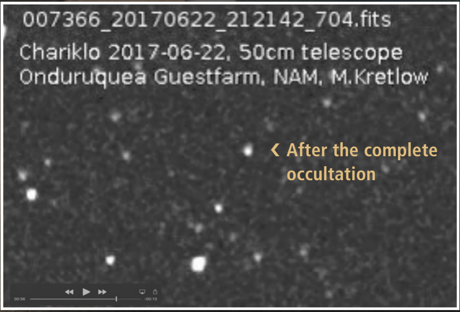
Mike Kretlow, IOTA/ES, mike@kretlow.de

Abstract: A successful occultation observation of a 14 Gmag star by the Centaur (10199) Chariklo on 2017 June 22 using the IOTA/ES 50-cm “M2” portable Alt-Az telescope in Namibia is reported.









Earlier in this issue of JOA (page 13) I have reported the observation of an occultation by the Centaur (10199) Chariklo on 09 April, 2017. The preparation for an observation campaign of another occultation on June 22 of this year, visible from nearly the same areas in Namibia and South Africa, was also mentioned. Altogether three favorable occultations, two observable from Southern Africa, another one visible from South America, are predicted for 2017. I traveled again to Namibia to observe the occultation with the IOTA/ES portable 50-cm telescope which was used for the April 09 occultation and which has been left in Namibia to be used in June again. As in April, the team consisted of several observers from France, Germany and Namibia. Fixed and portable telescopes (between 30 cm and 80 cm aperture) were used. In total 9 observers at 7 stations (6 different locations) were operating in good weather conditions. While the most southern station (Hakos Guestfarm) was outside the main body shadow (but successfully recorded an occultation by the ring system), all others stations could record an occultation by both the ring system and the main body. For the first time four different, positive chords of Chariklo (and five for the ring system) were obtained. In conclusion the June 22 Chariklo observation campaign was a full success (the second one after April 09).

Station	Telescope	Observer(s)
Outeniqua Guestfarm	30-cm Meade SCT	Francois Colas, Josselin Desmars
Onduruquea Guestfarm	50-cm Alt-Az telescope “M2”	Mike Kretlow
Cuno Hoffmeister Memorial Observatory	36-cm Celestron SCT	Michael Backes, Rhodri Evans
Cuno Hoffmeister Memorial Observatory	40-cm Alt-Az telescope	Erick Meza
ATOM (H.E.S.S. site)	80-cm telescope	Felix Jankowsky
Tivoli Astro-Farm	36-cm Meade SCT	Lucie Maquet, Konstantin von Poschinger
Hakos Astro-Farm IAS	50-cm telescope “AK-3”	Wolfgang Beisker

Journal for
Occultation Astronomy

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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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http://www.occultations.org
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This site contains information about the organization known as IOTA and provides information about joining

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