Journal for
Occultation Astronomy

2012–03

FORMERLY OCCULTATION NEWSLETTER

Next event in 105 years:

Venus "nearly" covers the sun!

© This impressive photo was captured by G. und H. Denzau at the eastern coast of Germany

Journal for Occultation Astronomy

Dear reader,

since the beginning of this year and until now we only had a little bit of luck in observing TNOs occultations that were predicted. On the 17th of April none of the observers from Central Europe to southern Africa could record an occultation by Quaoar. The only explanation could be that this object passed through a gap that existed between the Canary- and Cape Verde- Islands. The May 27th Quaoar event only delivered some marginal occultations data too. The better known orbit of Pluto did not even lead to better data because of marginal seeing-conditions in Europe concerning its June 14th occultation. Due to the fact that we like to oversee the atmosphere of Pluto and to find out whether Quaoar has one too it would be necessary to use a 16 bit CCD-camera. By sure the WATEC is a very good CCD-camera it is still an 8 bit system – I wonder if there will be a 16 bit camera like the WATEC and at a affordable low price too: If there is one please let us know. In case there is no stellar occultation by one of our solar system objects for you location you could search for extra-solar-planets: Have a look at Toby's "Call for Observations".

Hans-Joachim Bode

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In this issue:

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Journal for
Occultation Astronomy

Learning from two recent asteroidal occultations

Dave Herald · Murrumbateman · Australia

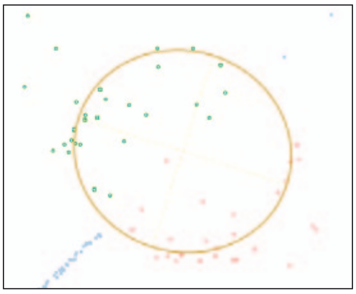
In recent times there have been two extremely well-observed occultations. The first was an occultation of a 3rd mag star by 472 Roma on 2010 July 8, widely observed across Europe with 231 reported stations. The second was the 2011 July 19 occultation by the binary asteroid 90 Antiope, well observed in the US from 57 stations with 46 recording an occultation.

Such well-observed events present a great opportunity for learning. The results from the Roma event turned out to be very disappointing, with the asteroid profile being very poorly defined. The Antiope event resulted in an excellent profile of both components of this binary asteroid – but when the data was looked at in detail to investigate the diameter of the star, a number of issues surfaced.

This paper discusses some issues about image saturation, looks at deriving the diameter of the star from the light curves, and explores how our processes can be improved.

Image saturation

The Roma occultation was anticipated with great expectations. The star was bright, so it would be an easy event to observe. And the star had a relatively large diameter, such that interesting light curves would be expected. In practice these two factors resulted in a set of reported observations that lacked consistency, such that the results can best be described as extremely disappointing – as shown in the following plot of the reported occultation times derived from video recordings.



Clearly the fact that the occultation events were gradual adds a complication to the measurement of the video recording. We can reasonably assume that all video observers reported times corresponding to 50% light level (which is the appropriate level when stellar diameter effects are significant). However the extent of the scatter is such that it cannot be explained by assuming some observers reported times corresponding to the 25% level (appropriate to Fresnel diffraction) or corresponding to a zero light level.

At the time of the observation, most people used LiMovie to measure the light curve of an asteroidal occultation. Importantly, the measurement methodology used in LiMovie at that time was something called Aperture Photometry. While aperture photometry is a standard methodology, it has limitations if there is any image saturation present. And because the Roma occultation involved a very bright star, image saturation was almost certainly present in many of not most video recordings.

To explore the effects of image saturation on photometric measurements, you need to understand how images are measured. In broad terms, there are two basic methods:

1. **Aperture photometry.**

   In this method:
   a. the value of each of the pixels in a measurement region are added together;
   b. the values of each of the pixels in a surrounding region representative of the background are added together;
   c. the value from (b) is proportioned by the ratio of the area of the pixels in (a) to the area of pixels in (b); and finally
   d. (c) is subtracted from (a) – to give a measurement of the light from the star.

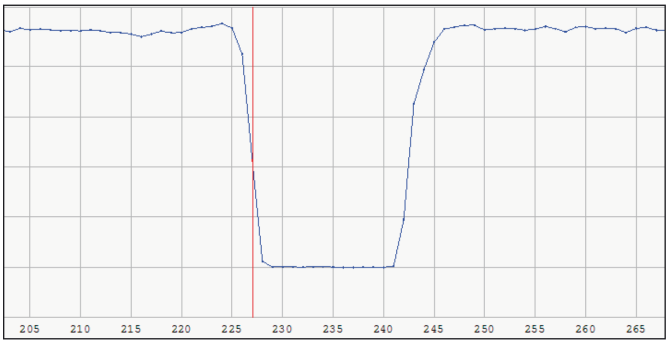
   Saturation has the effect of limiting the value that a pixel can have when measured in step (a). Consequently if saturation is present, aperture photometry will under-report the true value of the light signal. With an „instantaneous" occultation, this is of little consequence. However with a „gradual" occultation, the light level at maximum light will be under-valued, while the light level at low light levels will be correctly measured (as there will be no saturation) – with the result being a measured light curve that does not properly represent the true variation in the light level.

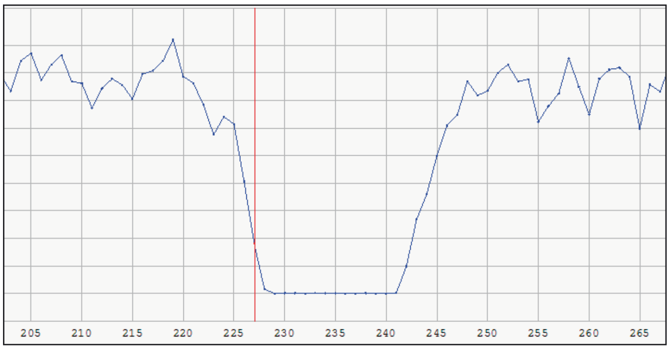
2. **Point Spread Function (PSF) photometry:**

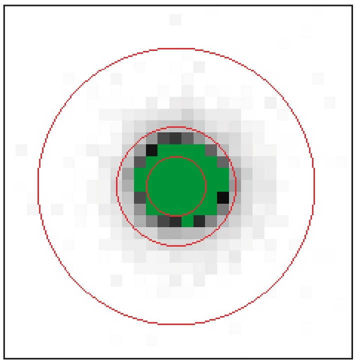
   For a well-defined star image, the light distribution of a star on the detector has the form of a Gaussian distribution. PSF photometry fits a 2-dimensional Gaussian curve to the values of the pixels. In this process, pixels that are at or near to the saturation level are disregarded – as they do not represent a valid measurement. The light measurement value that is returned represents the height of the peak of the Gaussian light curve, rather than the sum of the pixel values. Pixels that are affected by saturation are excluded from the determination of the height of the Gaussian light curve – and as a result the measurement is unaffected by image saturation. A separate measurement of the background level is also made – for subtraction from the light measurement value.

Interestingly, when image saturation is present, the maximum light level measured with aperture photometry will exhibit a lower level of noise than that measured with PSF photometry. The reason is that in aperture photometry many of the pixels will be saturated and have a fixed invariant value, giving a false reduced noise level, whereas the PSF measurement ignores those saturated pixels and estimates the maximum light level from the unsaturated noise-affected pixels.

The difference between aperture photometry and PSF photometry are illustrated in the following two plots obtained from a video recording of the Roma event. The measurement was made using Tangra, with post-measurement reprocessing using aperture photometry (first light curve) and PSF photometry (second light curve).







The following plot of the stellar image from the video at full light shows the region of saturation in green. As can be seen, the stellar image is heavily saturated, with over 40 pixels being saturated.

Comparative observations to be made about these light curves are:

- The difference in the noise level at maximum light level – the noise in the aperture photometry light curve is undervalued because of extensive image saturation
- The light curve from the aperture photometry exhibits steeper sides than that measured with PSF photometry
- The red line is positioned at the point of 50% light level on the aperture photometry light curve. That same line is located on the PSF light curve at around the 25% light level. That is, the time reported from the light curve measured using aperture photometry is in error, having been adversely affected by the image saturation.

It may additionally be noted that the PSF measurement, by its nature, is a more accurate representation of the actual light curve recorded on this image-saturated video.

There are several important points associated with an understanding of the two basic measurement techniques. They are:

1. Image saturation is not an issue if the video is measured using PSF photometry – **but only if the image is properly focussed.** PSF measurement assumes the image of the star is point-like, such that a Gaussian curve can be fitted to the star image. De-focussing an image to avoid saturation means that the star image is no longer point-like – such that a Gaussian curve cannot be validly fitted. Similarly, images that are highly distorted (eg large coma arising from the camera being poorly aligned with the optic axis) are not well suited to PSF photometry.
2. PSF photometry is not suitable if the object being measured is faint,
   as there will be insufficient data in the pixels to reliably fit a Gaussian curve;
3. Aperture photometry is well suited to faint objects;
4. Aperture photometry becomes inaccurate whenever image saturation occurs. In particular, the measurement of the light level becomes invalid if many pixels are saturated. However a small amount of saturation (e.g. just 2 or three pixels in the centre of a stellar image) will have minimal effect.

If an occultation event is substantially instantaneous, image saturation is not an issue – you will have full light in one frame, and zero light in the next. However when the event is 'gradual', image saturation will result in the measured light curve differing from the real light curve – and this can result in misreporting the time corresponding to the 50% light level. Also the presence of image saturation will render the light curve unsuitable for determination of the star's diameter.

With occultations of relatively bright objects, it is frequently asserted that observers must avoid image saturation at all costs. The usual advice is that if image saturation is likely - defocus the image so that the star image is distributed over a larger area, thereby avoiding saturation. This is generally bad advice. The correct advice is:

A. If you are measuring a video with bright objects, make sure you use PSF photometry for the measurement. **Do not use Aperture photometry. Do not defocus the image.**
B. If you are measuring a faint object, use Aperture photometry (and do not defocus!)
C. If you are measuring an intermediate brightness object, you can use either PSF or aperture photometry – remembering that the end objective of the measurement process is to obtain the highest possible signal-to-noise ratio in the measurement.
D. If you feel you must defocus the image, it is absolutely essential that you defocus enough to ensure image saturation is not possible. If you fail to do this, the ability to reliably measure the brightness of the star during the event will be compromised.

Note that both Tangra, and recent versions of Limovie (0.9.97.3g and later), provide options to measure images using either PSF photometry or Aperture photometry. This choice should not be seen as an obscure issue that can be ignored. Rather users should get into the habit of:

- Bright object – use PSF photometr
- Faint object – use Aperture photometry

■ Intermediate object – use whichever gives the cleanest light curve in the particular instance.

Star diameter analysis

The Antiope event involved 57 stations, of which 46 observed an occultation. [For 5 of the stations that observed a Miss event, the star passed between the two components of Antiope!] The great majority of observations were made using video – with all the light curves displaying a gradual event, characteristic of the effects of a significant stellar diameter. This resulted in over 60 light curves that could be analysed to measure the star's diameter.

The star occulted by Antiope was the 6th mag star Hip 112420. This star is quite red, with B-V = 1.664, and V-I = 2.100. While there have been no direct measurements of the diameter of this star, the diameter can be estimated as 2.3 mas using the magnitude and colour of the star. In comparison, the apparent diameter of each of the components of Antiope was about 68mas.

If you assume:
- Fresnel diffraction makes no significant contribution to the observed light curve; and
- The occulting limb can be approximated as a straight edge; and
- The brightness of the stellar disk is uniform – that is, there is no significant limb darkening on the star

you can easily generate a theoretical occultation light curve based on an assumed apparent diameter of the star, using the rate of motion of the occulting limb in a direction normal to that limb.
Of these factors, for this event:
- Fresnel diffraction was expected to contribute about 0.2mas for light drop of 2 mag, and 0.5mas for a light drop of 5 mag – much smaller than the expected effects of the diameter of the star;
- The fact that the apparent diameter of the star is expected to be around 4% of that of the asteroid means that a straight-line approximation to the limb of the asteroid is reasonable. [In comparison, if the star was 50% of the diameter of the asteroid, the curvature of the limb of the asteroid cannot be ignored. Similarly for the Roma event the star's diameter was too large compared to the asteroid's diameter to treat the limb of the asteroid as a straight line];
- Limb darkening can be ignored in the first instance, noting that its primary effect would result in a diameter that is smaller than the actual diameter;
- The orientation of the limb of the asteroid for each observed chord can be measured from the usual reduction plot of all observed occultation chords; and
- The rate of motion of the star relative to the asteroid is well known – being an essential quantity in the analysis of the occultation chords. For the Antiope event, the rate of motion was about 2.49mas/sec – with the exact value depending upon the observer's location (which changes the contribution of the Earth's rotation to the apparent motion of the asteroid).

Accordingly within the program Occult I built functionality to:
- Measure the rate of motion of the star in the direction normal to the limb, for each occultation point – with the user setting the orientation of the limb on the basis of estimating the best alignment to adjacent observers;
- Generate a 'theoretical' light curve that is based on that relative rate
  of motion, and an assumed diameter of the star;
- Compare that light curve with the observed light curve, using values imported from the csv file generated by either Limovie or Tangra, with tools to assist in fitting the theoretical light curve to the observations; and
- Derive a final measurement of the stellar diameter as a mean of the results from each of the individual light curves – with a system of weighting to reflect uncertainties in the estimated limb slope, and the quality of the observed light curve.

This functionality is present in Occult 4.1.0.0.

The fit of the theoretical light curve to the observed data involves:
- Time displacement of the theoretical light curve relative to the observed data, to obtain the best match in event time;
- Variation of the theoretical light curve by changing the nominal star diameter;
- Computation of the standard deviation of the differences between the theoretical light curve and the observations, and display of the distribution;
- Recognising that the noise level in a video signal is strongly dependent on signal level – computation of the χ^2 statistics of the differences between the theoretical light curve and the observations, and display of the distribution; and
- Adjusting the time displacement and the star diameter to obtain minimums in both the χ^2 statistics and the standard deviations.

One of the issues with this process is that the event time reported by the observer is dependent upon how the light curve has been interpreted. Any 'errors' in the interpretation of the light curve will result in a consequential displacement of the end of their observed chord relative to the adjacent observers, and thereby affect the measurement of the local limb slope from the usual plot of events. Accordingly the process of analysing the light curves to determine the stellar diameter needs to be iterative. That is, involve the steps of:

1. An initial determination of event times;
2. Determination of limb slopes for each event, by comparison with adjacent chords;
3. Analysis of all the light curves to derive a best fit of a theoretical light curve to the observations;
4. Re-determination of the mid-event time from each light curve; and
5. Repeat steps 2 to 4.

More details of how the functionality in Occult works is described in the Help topic associated with the **Star diameter analyser** tool in Occult.

The diameter of Hip 112420 from my analysis of 61 light curves from the Antiope observation is 2.14 ± 0.03 mas. This value is quite close to the estimated diameter of 2.3mas.

However the uncertainty value needs to be treated with caution. The uncertainty is derived from the variance in the diameter determined from each of the light curves. It assumes that the uncertainties in the various factors used to generate a diameter from a specific light curve will result in a scatter that is normal about the derived diameter. However this is generally not the case – and a more realistic determination of the diameter is 2.1 ± 0.1 mas.

Availability of data to re-analyse

Historically occultation results have generally involved a fairly brief transition from full light to minimum light – lasting no more than a small number of video frames. In that context the derivation of event times is straight forward, and the reporting process can sensibly be limited to the user-determined event times – as has been the case for the last 40 years....

However when the event involves transitions that last a significant number of frames, the proper interpretation of the light curves can be more complex. Furthermore when stellar diameter effects are significant, the correct interpretation of the light curve may depend upon the results from adjacent observers. Additionally the precise shape of the light curve may contain information that is relevant to the correct interpretation.

For the Roma event, very few of the original video recordings are available for independent analysis. Similarly very few .csv files obtained from Limovie, or .lc files from Tangra, are available. This means that there is almost no capability to re-process the measurements of the videos to ensure saturation has been properly dealt with, and to measure the diameter of the star. This is unfortunate.

The Antiope event offered much greater promise for more detailed data analysis. However the practical difficulties I came across when analysing the data were:

a. .csv files containing the measurements of the videos were available for 42 sites. No .csv file was available for four video sites that recorded an occultation.
b. To validate the event times, and confirm the correctness of the derived limb slopes, one must be able to associate a frame in the .csv file with a time. Some of the .csv files included OCR measurement of the video-inserted time stamp – such that a linkage to time was available. I was separately provided with a linkage between frame numbers and time for several other .csv files. However I was only able to link the .csv data to UT times for 25 of the 42 .csv files. The good news is that for the majority of sites, the reported times and the times derived from my fitting of the light curves were in close agreement. The bad news is that for 17 of the video sites I have been unable to independently verify that the reported time is consistent with my analysis of the individual light curves. [As a matter of principle, this is not a good situation – observational results should be open to re-assessment. More specifically, my analysis to determine the stellar diameter from all the individual light curves has been compromised.]

When following up a number of queries associated with the observations, the following issues surfaced.

a. For one site, the reported time for the reappearance was in error by about 1 second when compared to the video recording – and has since been duly corrected. [This is a clear example of the value of having the observational data readily available for re-assessment – simple reporting errors can be readily identified and corrected.];

b. For several sites of one multi-deployment array, the reported times had been adjusted by exactly 1 second. This adjustment occurred because the times derived from the video appeared to be 'out' by about 1 second when compared with other observations, and an assumption was made that this was caused by a 1-second time error in the KIWI-OSD used to calibrate the camcorder internal clock before and after the event. Unfortunately detailed consideration demonstrated that the basis for this correction was unsustainable. The most likely explanation for the apparent time base errors is non-linear drift of the camcorder clocks over the several hours between the calibration points, resulting in an unrectifiable uncertainty in the time base.

As a result of the situation in (b), the following guidelines have been established for establishing the time base for a multi-station deployment reliant on camcorder internal clocks:

A. The observer should ensure they are using an idiot-proof time stamping device that allows hot-connection of video cameras without losing the time-base, and has clear indication of validity of the almanac – such as the IOTA-VTI.

   Note: Many IOTA observers have KIWI-OSD time inserters acquired before the IOTA-VTI was developed. These devices have known timing issues if the almanac is not updated and/or if cables or power have been disconnected during the timing, and so continued use of these time inserters is not recommended. If the observer continues to use the KIWI-OSD, allow 15-20 minutes lead time to ensure the almanac has been updated, and then press the reset button to ensure the time is valid.

B. The observer must perform time stamping of the camcorder **at each deployment site** – both at set-up, and collection – so that
   a. the reliance on the camcorder clock is kept to the shortest duration possible, and
   b. minimises changes in environmental conditions during the interval between time stamps.

   Batch time stamping all camcorders before starting the deployment, and after all have been retrieved, is not acceptable - as it creates too high a dependency upon assumed linearity of the internal camcorder clock to ensure a reliable time base;

C. In the deployment process, observers need to ensure (as much as possible) that the camera and camcorder are at ambient temperature prior to deployment – so that they are not undergoing significant temperature adjustments in the first 10 mins or so after deployment.

We should be striving to be in a position where we can (when necessary) re-analyse the data – both to demonstrate the validity of any conclusions reached from the data, and to perform a more detailed analysis than simply derive the occultation D and R event times. In the context of video recordings, this requires (at a minimum):

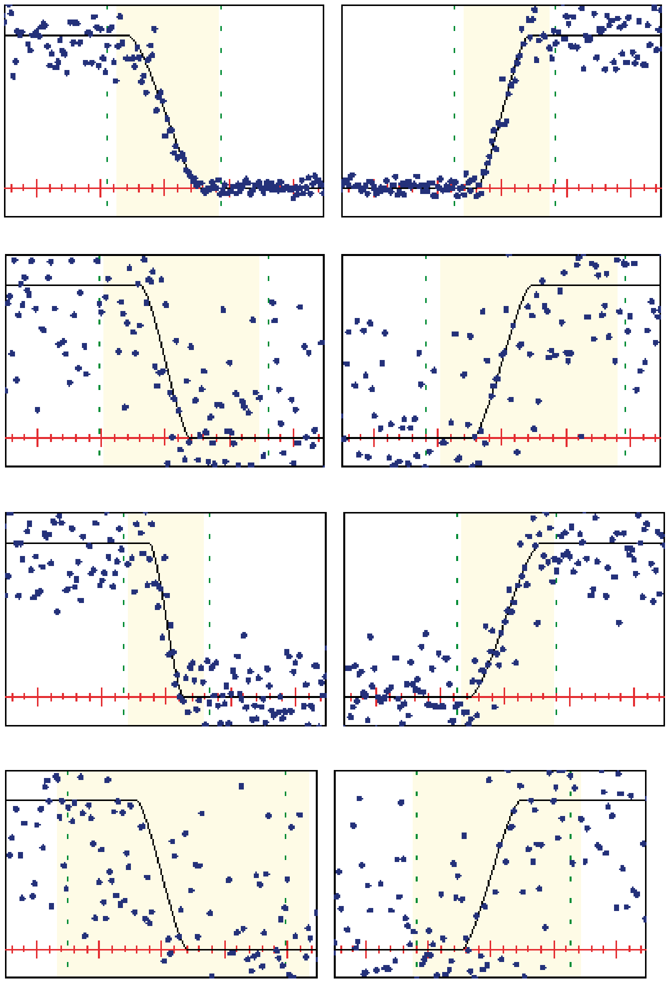
- Availability of a csv file containing the measurements of the video used to report the event times [this can be created by both Limovie and Tangra], or a Tangra .lc file.

- Availability of the linkage between the video and UTC. This can be achieved by any of the following:
  - With Limovie, including the OCR interpretation of the video-inserted time stamp in the measurement
  - With Tangra, specifying the start/end times at the end of the measurement, for inclusion in the .lc file
  - Separately writing down the video-inserted time stamp on specified frame numbers – preferably a frame near both the D and R times (so that the presence of any dropped frames between the events can be detected)
  - For multi-station deployments – (i) the relationship between the video-inserted time stamp and the internal clock at the pre and post event times, and (ii) the internal clock value at a frame near both the D and R times.

One of the problems in sharing videos is the inevitably large file size – usually far too large for an email attachment. However one of the very nice features of Tangra is that it can create a 'light curve' file (.lc) that contains the relevant portion of each video frame surrounding each of the measured objects, together with a record of where the measurement aperture was located. The .lc file size is almost always small enough that it can be reliably sent as an email attachment, enabling the video to be easily disseminated to those that need it. [Furthermore, if you have the .lc file, you can remeasure the event with different settings – such as changing between aperture and PSF photometry.].

Data quality

One of the 'interesting' results from reviewing the Antiope data was the widely variable quality of the video recordings. The following are four examples of light curves from the Antiope event showing a best-fit light curve used to derive the stellar diameter. I would loosely refer to the examples as good, average, poor and useless:



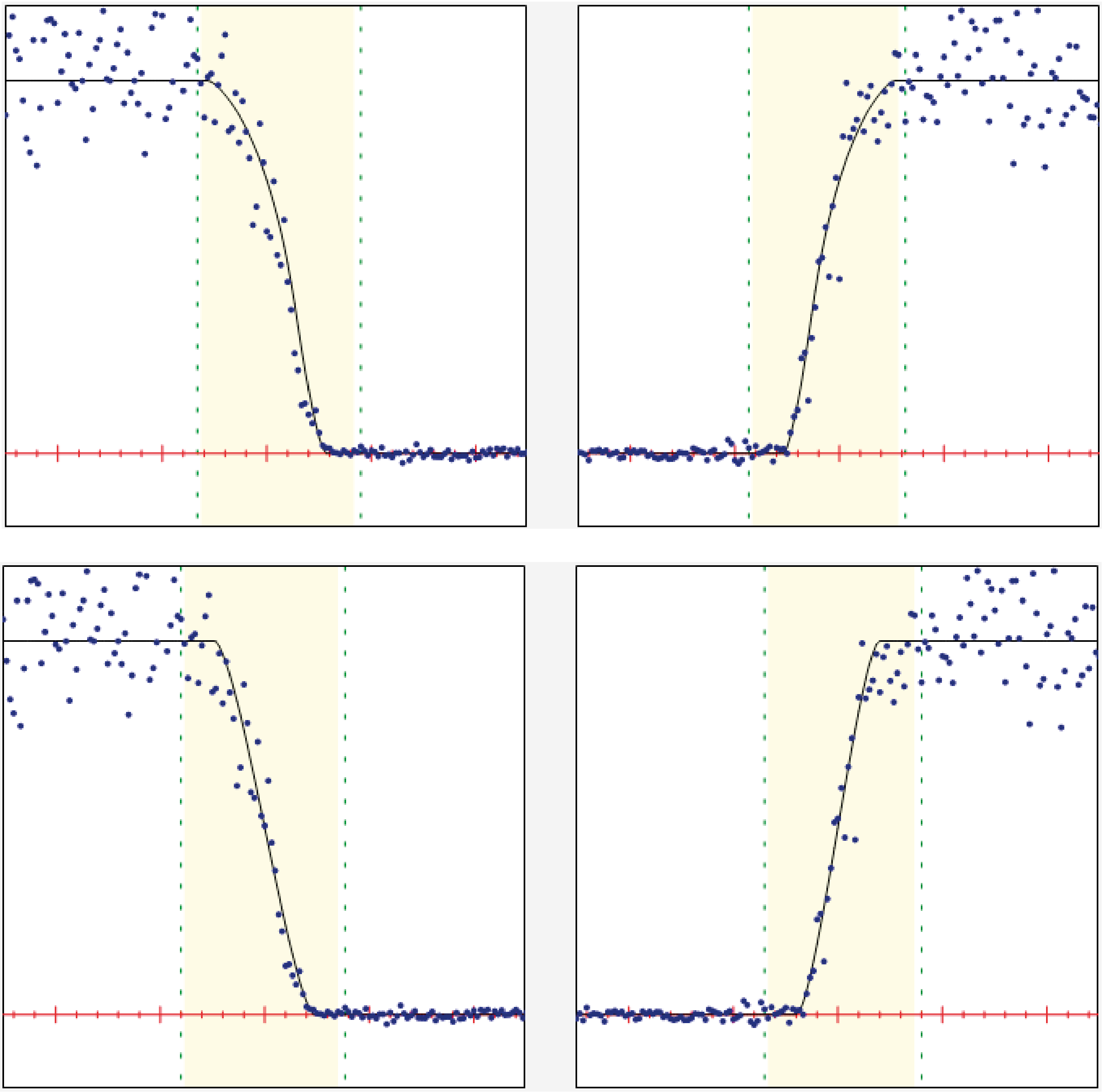
The primary point to note here is that if the transition from full light to minimum light occurs over only a few frames, the event time can be determined quite reliably under a wide range of noise levels. However when the light transition extends over many frames the uncertainty in the event times becomes rather large, and the ability to extract any information about the stellar diameter is reduced or lost. In short, you should aim at having a light curve that clearly shows the event, and avoid light curves like the last two of the above examples.

Effects of gamma

For a small number of observers of the Antiope event, the fit of the theoretical light curve to the observed data indicated a stellar diameter that was significantly smaller than that derived from the majority of light curves. A particular example is:

The fit superficially looks good, with diameter solutions of 1.72 and 1.36mas (compared to an overall solution of 2.1mas). However on closer inspection there are problems with the fit of this light curve. If properly fitted, the data points should be distributed roughly equally on each side of the fitted curve. However on both light curves (but particularly evident on the R light curve, the data points near the top of the light curve are almost all located below the theoretical light curve for a period of the expected full light level. This gives rise to the question – are these light curves affected by gamma?

The difficulty with making corrections for gamma is that it can only be done at the measurement stage, by correcting the reported values of each individual pixel for the gamma correction. However when gamma is less than 1 the effect is similar to the effect of saturation. That is, the value of highly-illuminated pixels is reduced compared to other pixels. As a result, the effects of gamma less than 1 can be crudely approximated as being equivalent to the effects of saturation.



Within the Star Diameter Analyser of Occult, I have included a capability to adjust a theoretical light curve as measured using aperture photometry, for the effects of saturation. The following plot of the above event shows the theoretical light curve on an assumption that the star image is heavily saturated (equivalent to a small value of gamma).

As is apparent, the theoretical light curve has a much better distribution of observed points on either side of the light curve at the top part of the light curve. The diameter solutions for these two light curves are 2.05 and 1.85mas – values which are consistent with the overall solution of 2.1mas. Note that the event times as defined by the 50% light level in the light curve are also slightly different from the previous plot.

Unfortunately I have no knowledge about whether or not the particular observer was recording this event with a non-unity value of gamma, and so the attribution of gamma to this light curve is speculative.

However the essential learning from this is that for events that are expected to involve stellar diameter issues, observers need to make sure they know the level of gamma they are applying when making the recording. In this, they need to be aware of both the inherent gamma of the camera they are using, any gamma applied by the camera controls (e.g. the Watec 120N camera control) and any gamma (or contrast) setting available and used in the recording software (e.g. the controls available in VirtualDub with respect to the Video Source).

It is worth noting here that there may be good reasons for setting gamma to something other than 1. For example, using a gamma less than 1 will enhance the signal change at occultation of faint objects against a dark background. Conversely the use of a gamma greater than 1 will enhance the signal change at occultation of objects faintly visible above a bright background.. In both instances, the small light change that will be recorded will be essentially linear. Gamma only becomes a problem if:

You are trying to translate a change in light level to a change in stellar magnitude; or

In interpreting the shape of a light curve when a large light change has been recorded (e.g. bright object disappearing from visibility) such that the change of light from full to minimum is non-linear because of the non-linear nature of gamma when applied to large light changes.

In short – there can be good reasons to record an event with a gamma that is not 1. But if you do this, you should make sure you 'reverse' the gamma when you measure the video recording so that the measurement properly reflects the 'true' change in the light signal.

Summary

Some key learning from these asteroidal occultations is:

Never defocus your images to deal with saturation. Rather make sure you measure the video using PSF photometry;

Ensure you save your measurements of the video in a csv file (Limovie/Tangra) or the Tangra .lc file so that it is readily available for re-analysis. Also ensure a linkage from the frame number to UT is provided.

Ensure your raw video is available if needed. The Tangra .lc file is well suited to email distribution of the raw video.

Strive for the cleanest possible video recording.

Understand the gamma setting that has been used when recording the video. When measuring the video with Limovie or Tangra, 'reverse' the gamma – so that the measurement is based on a gamma of 1.

Journal for
Occultation Astronomy

Introducing GPS-ABC
A GPS based precision clock and occultation timer

By Tony Barry and Dave Gault · 20 April 2012

Encouraged by the success of IOTA-VTI[1], the developers have added another device to the pedigree of precision timing equipment designed to support the occultation observer, specifically in the case of GPS-ABC – for the visual observer or for use as a backup for the video observer.

Historically, thousands of occultation observations have been performed worldwide using shortwave radio transmissions as the timebase. However gradually the radio based services are closing down their transmitters and as of the date of writing, only radio WWV and WWVH can be received. The observing technique is simple, where the observer would arrange for a tape recorder to record both the sound of the shortwave time transmissions and the sound of his/her voice as called from the telescope, and would call "gone" when the star disappeared and "back" when the star reappeared – or something similar. Afterwards the audio recording is analysed to retrieve the timings. However, if the radio reception is poor (more noise than signal) this may prove to be difficult. A device with a clear and accurate time signal would improve the reliability of retrieving the time of the observation.

Recently video observations, particularly those that are Video Time Inserted (VTI), have become the norm, and it might be assumed that visual observations have become "old hat". But this is not so, as seen in the 2011 July 19th (90) Antiope asteroid occultation2 where three visual observers made valid observations out of the total of 58 observations, the balance being video or photoelectric in nature. Sure, video seems to have taken over the scene, but with the proliferation of huge Dobsonian telescopes, a keen visual observer can still make a valuable contribution if suitably equipped with a device that gives a clear and accurate audio time signal.

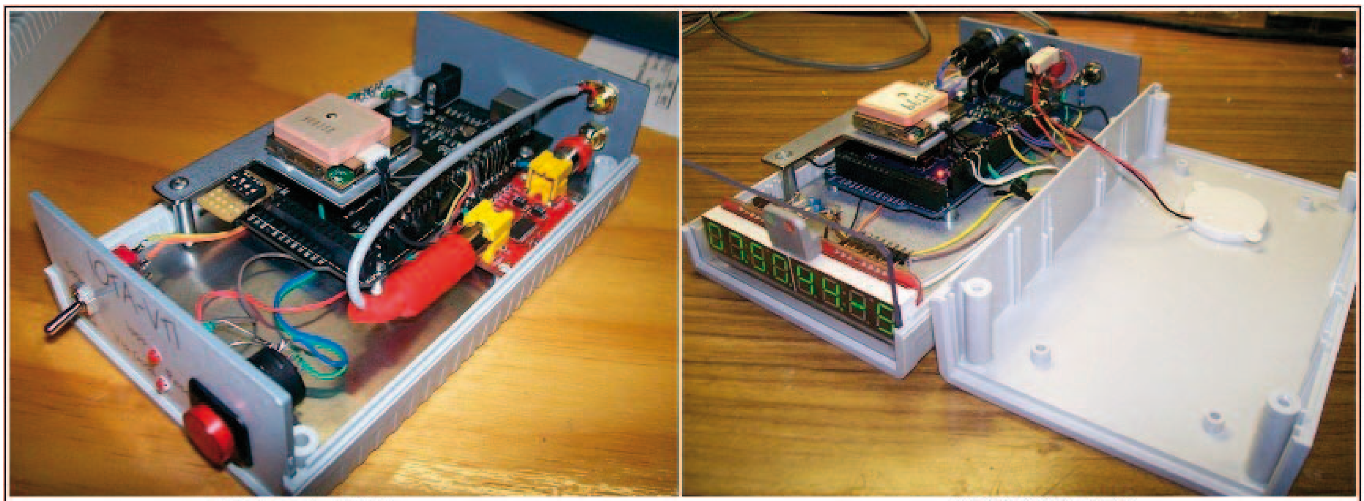
The pedigree of GPS-ABC can be readily seen by comparing these images of some prototypes:

Note: The red video titler PCB of IOTA-VTI is replaced with two 7-Segment LED arrays that display time, satellite fix details and (eventually) geo-location information. Of course the circuit wiring of each device is different in many respects, but the same type of processor board and GPS module are used in both devices. Also GPS-ABC has a piezo buzzer that is programmed to give a clear and coded audio time signal so that recordings of occultation observations can be easily analysed.

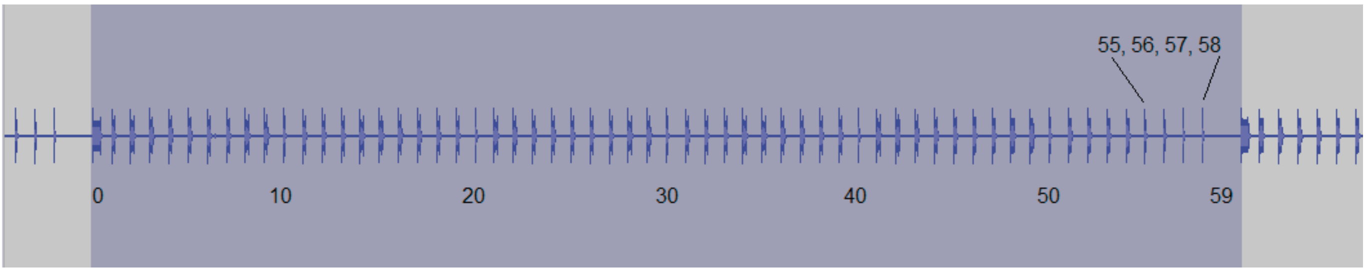
A detailed look at the front of the second prototype of GPS-ABC (P#2) shows the time and the number of satellites in the GPS fix. Note: The red 1pps LED is on, indicating the 7-Segment array is changing the seconds, from 05:21:39 UT to 05:21:40 UT.

If the piezo buzzer is turned on, a coded audio beep is sounded at the instant of the second. The coded beep format is:

Every second (except those listed below)	=	normal beep
Beginning of the minute	=	long beep
10th, 20th, 30th, 40th and 50th seconds	=	short beep
55th, 56th, 57th and 58th second	=	brief beep
59th second	=	silent (no beep)



IOTA-VTI_P#4.0 GPS-ABC_P#2

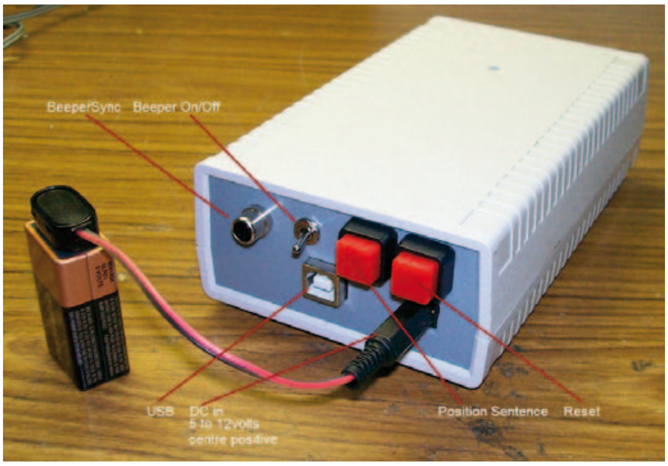


This is how Audacity[3] displays the sound of the GPS-ABC coded beep. (Alternative is Apple's Garage Band[4])

Note1: the silent 59th second, the long zero second and (a bit harder to see) the short 10th second beeps.

Note2: for a complete description of how to make an audio analysis of an occultation observation recording, see my article; Analysis of Occultation Events Using Audio Techniques5.

A detailed look at the rear of GPS-ABC_P#2 reveals the following details, clockwise from top-right

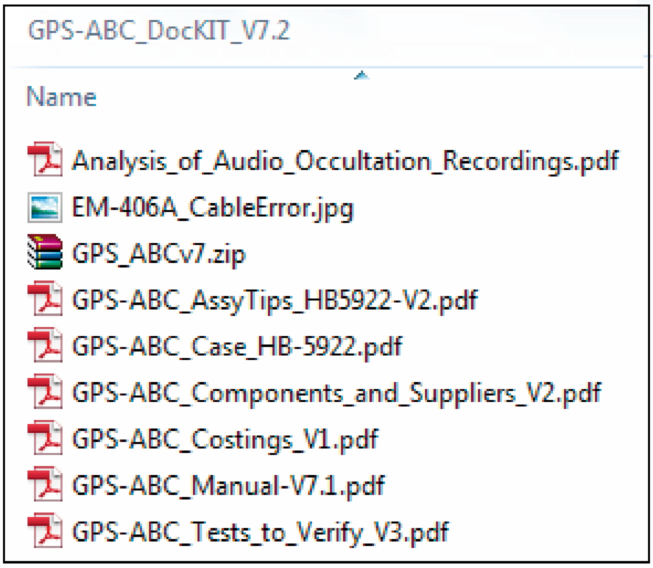


- the Reset push button
- the 8 to 12 volt DC (centre positive) socket
- the USB socket, used for uploading the GPS-ABC code and to power the device from a laptop
- Beeper Box synchronisation socket
- Beeper on/off switch
- the Position Sentence push button (not implemented yet)
- A good quality 9v alkaline battery will power the device for at least 2 hours.

How to acquire a GPS-ABC? At the time of writing, the device is offered open source, meaning you contact the authors and we will send you a Document Kit which contains the Manual and other documents that describe where to purchase the individual components and how much they cost, as well as a document that describes how to modify a plastic case the authors have used in the construction of the prototypes.

Then, using simple hand tools and a soldering iron, you make your own GPS-ABC.

Also contained in the kit is the source code you will upload into the device, once the construction is complete.


GPS-ABC_DocKIT_V7.2

Name

Analysis_of_Audio_Occultation_Recordings.pdf
EM-406A_CableError.jpg
GPS_ABCv7.zip
GPS-ABC_AssyTips_HB5922-V2.pdf
GPS-ABC_Case_HB-5922.pdf
GPS-ABC_Components_and_Suppliers_V2.pdf
GPS-ABC_Costings_V1.pdf
GPS-ABC_Manual-V7.1.pdf
GPS-ABC_Tests_to_Verify_V3.pdf

This is an open-source project and subject to a Berkeley 3-clause licence, the details of which are spelled out at the end of the GPS-ABC Manual. This may change in the future if there is considerable interest in the device, sufficient to develop a Motherboard to aid assembly and reduce costs and the device may be offered as a ready to go product. Time will tell (excuse the pun).

There is a YouTube video made by Dave Gault that explains and demonstrates the device6.

At this point in time the authors consider this a useful device to be used as the time-base for occultation observations, and so we are pleased to offer it to the occultation community. For more details, please contact the authors7.

Tony Barry and Dave Gault

Notes

1) IOTA-VTI website - http://videotimers.com/home.html
2) 90 Antiope occultation – http://tiny.cc/k0w1cw
3) Audacity by soundforge – http://audacity.sourceforge.net/
4) Garage Band (Apple Platform) http://www.apple.com/au/ilife/garageband/
5) Analysis of Occultation Events Using Audio Techniques – see JOAv01n07 ***CHECK***
6) YouTube video – http://www.youtube.com/watch?v=adeX3HTqWCk
7) Dave Gault – dave4gee@yahoo.com.au

Journal for Occultation Astronomy

Analysis of Occultation Events Using Audio Techniques

Dave Gault

The use of an audio time-base for the successful observation of occultation events has a long history. From the early 1960s, David Dunham, Bob Sandy and others used reel-to-reel tape recorders and later cassette tape recorders, to record the sound of the short-wave time signal broadcasts of station WWV (Fort Collins, Colorado) or WWVH (Hawaii) as well as the sound of their voice calls from the telescope as the events occurred. There were a lot of other shortwave broadcast stations available in the past but sadly most have ceased transmissions. Our time signal station here in Australia was radio VNG which closed in 2002. Today, there are alternative methods to obtain an audio time-base, the best of which use the GPS as a basis of operations.

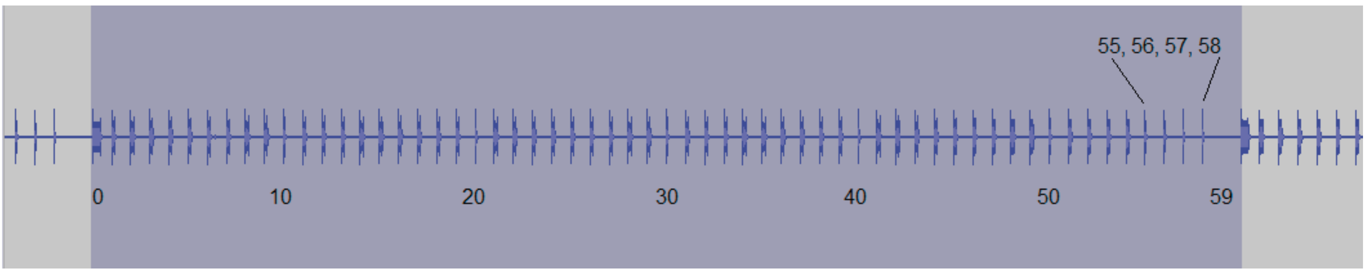
The recording of the observer's voice has a number of advantages over a stopwatch or some other device operated by the observer's hands;

> The voice is not as much affected by cold temperatures as the observer's fingers and so the observer's PE value might be more consistent.
>
> The microphone can be clipped to the observer's collar or lapel or even a microphone headset could be worn, that would free the observer's hands for other duties including controlling the telescope.
>
> The observer can give a commentary on the proceedings, noting indirect observing conditions like the presence of cloud, or eyepiece fogging, telescope re-pointing activities or passing traffic.
>
> The observer can instantly add comments that affect the observation directly, like the detection of a step-like event which occurs due to a double star, or a slow event which would indicate a large stellar diameter.
>
> Comments can be added immediately after the event occurred to explain how the observer felt about the event call and whether a larger than normal PE should be applied.

The best arrangement is to have a stereo recorder that is set up so that one channel records the sound of the timing device, and the other channel is devoted to the sound of the observer's voice. However a simple mobile phone recorder can be used as a make-do recording device.

The analysis of audio recordings is best performed using free software that is available over the internet. The author uses "Audacity" by Soundforge on the PC, and an alternative for Macintosh computers is "Garage Band". Stephen Russell first demonstrated this technique to me at the first Trans Tasman Symposium on Occultations – Auckland 2007.

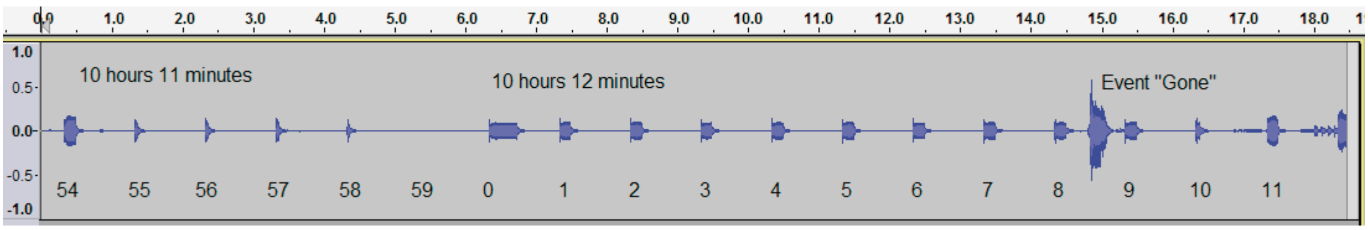
Here is what a minute recording of the audio beeps of GPS-ABC look like using Audacity.



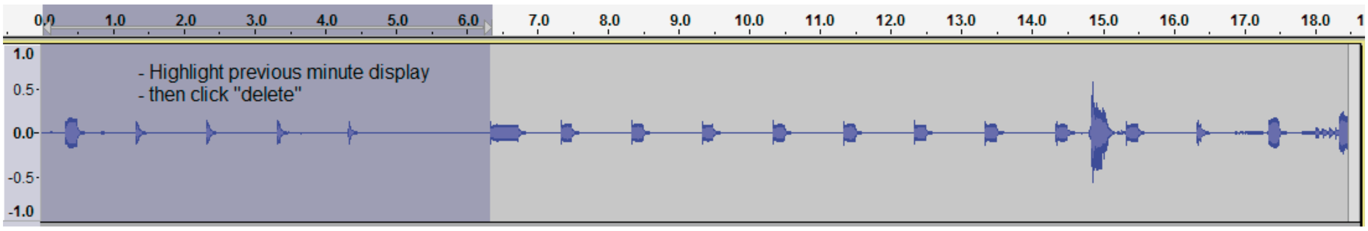
The long beep at the beginning of the minute, as well as the silent 59th second can be easily determined as well as the shorter 10th seconds beeps.

The steps to determine the time of an event are, (assuming the sound recording has been saved to computer, usually as a .wav file):

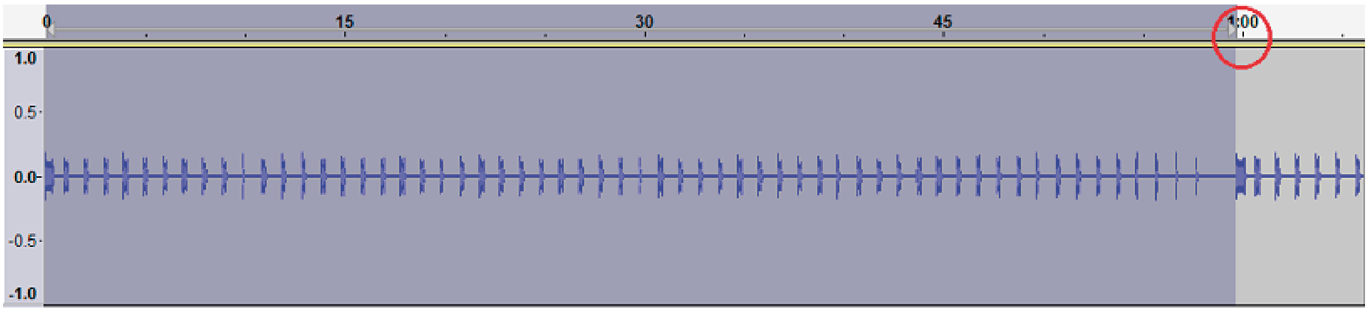
1) Open the file using Audacity or similar and note the silent 59th second



2) Highlight and delete the recording preceding the minute beep

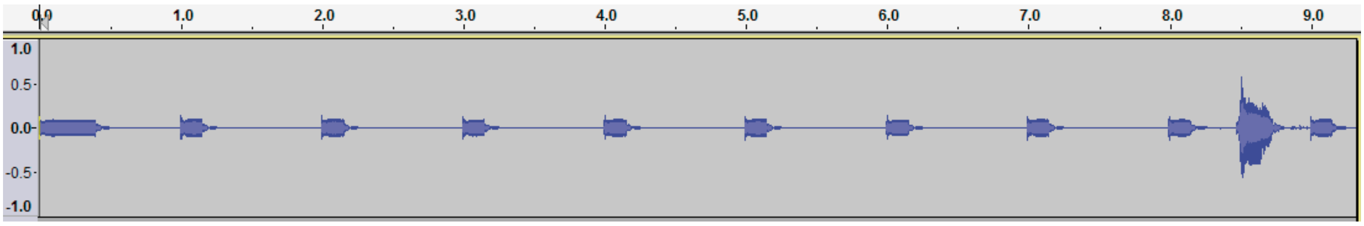


3) Note:- the scale at the top (in seconds) is now zeroed,

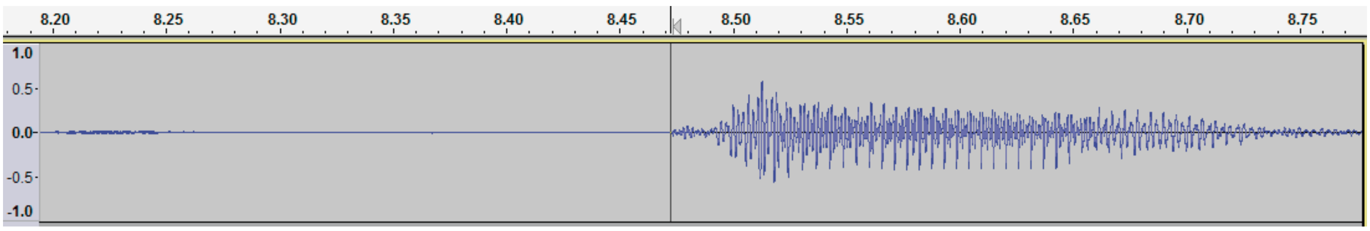


then check the scale at the beginning of the next minute. Any variations in record and playback speeds can be adjusted using the Audacity effect "Change Speed"

4) Read off the approximate time = 8 ½ seconds



5) Zoom into the "gone" event to closely examine the plot for the sound of the word.

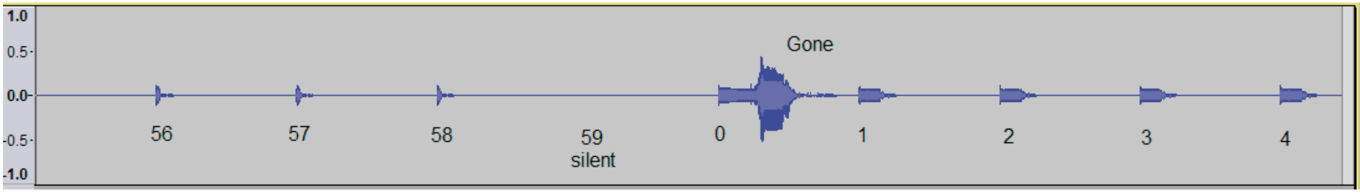


The beginning of the sound of the word "gone" is probably due to the sound of the movement of muscles in my throat required to make the "g" sound and so is the first instance of my reaction to the event. The raw event time is 10:12:08.472 UT

Of course the next step is to determine my Personal Equation (PE) value. This does not have to be performed for every observation, as PE is a subjective estimate based on measured values, adjusted by the feelings of the experienced observer.

The steps to determine the PE value are very similar to the above method, only this time the observer watches for the flash of the 1pps LED, for the beginning of the minute, which in the device GPS-ABC and the program BeeperSync is preceded by the silent 59th second, so the observer closes both eyes and opens them during the 59th second, and says "gone" immediately on seeing the LED flash.

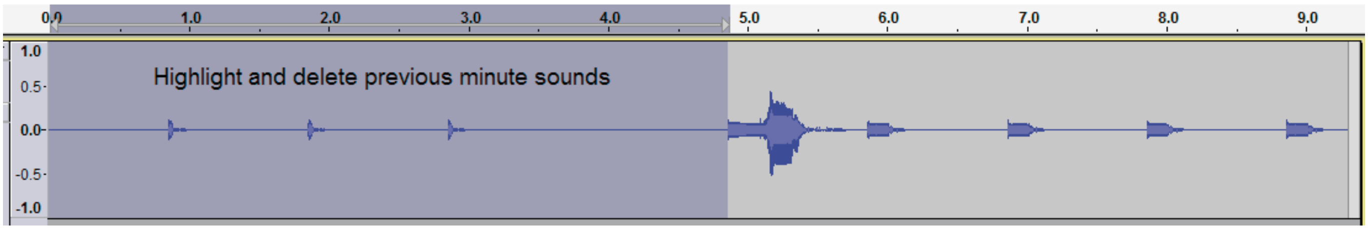
The Audacity recording plot looks like this;



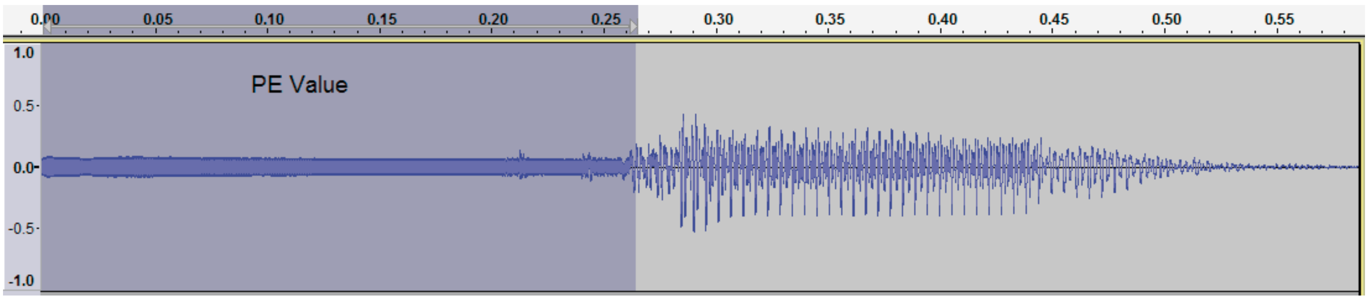
Note the word "gone" is louder than the time beep and can easily be distinguished.

The steps to determine the PE value are:

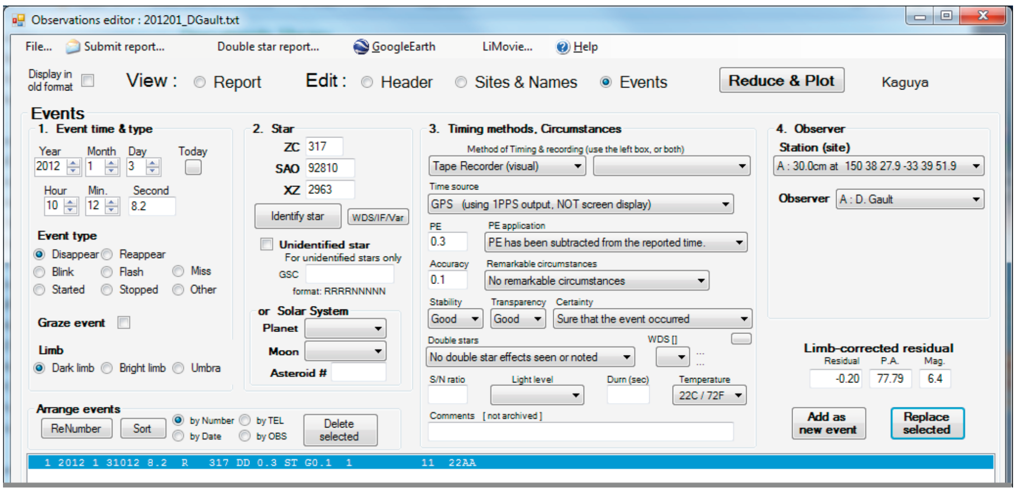
1) Highlight and delete the recording of the preceding minute:



2) Zoom in to examine the sound of the word "gone":



Note the PE value is shown as 0.26 and should be considered the base value in perfect conditions. In the real world, observing a star through at telescope the value should be considerably larger – probably between 0.3 and 0.4 would be realistic and probably larger still if the conditions are difficult or the event is a reappearance.



So, for this event, corrected event time is:

10:12:08.472 UT subtract 0.300 PE

10:12:08.172 UT

10:12:08.2 UT

rounded to the nearest 1/10th second.

Remember to insert your best estimate for the event accuracy.

If you have any questions, please email me at dave4gee @ yahoo.com.au … Dave Gault

Report on the Sixth Trans-Tasman Symposium on Occultations

By Jacquie Milner · milnerjacquie@gmail.com

Jacquie Milner from the Astronomical Society of Western Australia

The Sixth Trans-Tasman Symposium on Occultations (TTSO6) was held in Brisbane, Australia, on Monday 9th April 2012. It was held in conjunction with the twenty fifth National Australian Convention of Amateur Astronomy (NACAA XXV), which is held every second year over the Easter weekend at different locations around Australia.

Although the Symposium was only scheduled for one day several occultation related presentations were given beforehand during the main convention. Dave Herald and Dave Gault got things started with a presentation on the soon to be released USNO CCD Astrograph Catalog v4 (UCAC4) on Saturday afternoon. This will provide one of the most up to date catalogues for stars to magnitude 16, and has benefited from the testing of its star positions by comparing occultation predictions with actual results from amateur astronomers.

Sunday afternoon began with a summary of the last two year's activities for "Team Occultation", a group of observers in New South Wales and the Australian Capital Territory who come together to participate in grazing occultation expeditions in the Sydney-Canberra region. Then Dave Gault, Tony Barry and Hristo Pavlov introduced their latest development in the growing list of equipment being developed for occultation observers; the Astronomical Digital Video System (ADVS). This is basically an all-in-one package with a Flea3 camera feeding to a box with a GPS video time inserter and recording device. It aims to not only simplify the set up needed to capture an occultation, but also uses a new video file format that will reduce the amount of 'noise' generated in the recording of the video as well as minimise the file size of the video captured. The ADVS is still in development and is not expected to be available until 2013, when it will be produced on demand once it is ready to be marketed. (For more information see: http://www.astrodigitalvideo.com.au/)

Dave Gault reviews key features of the International Occultation Timing Association's Video Time Inserter (IOTA-VTI)

Participants at TTSO6

Afterwards Dave Herald presented some of the 3D models of asteroids now available via the DAMIT (Database of Asteroid Models from Inversion Techniques) project, which are obtained by combining asteroid occultation observations with photoelectric light curve inversions.

The Symposium was formally opened on Monday morning by the Royal Astronomical Society of New Zealand (RASNZ) Occultation Section Director Graham Blow, then John Talbot joined the meeting via Skype from New Zealand to present a summary of recent planetary occultation events from across the region. John was followed by Dave Herald summarising the best of the results from around the world in the last year or so.

Mohammad Mirbagheri told us about the new Middle East chapter of IOTA (IOTA-ME) and the symposium attendees were interested to note that not only was it apparent that the members there were mostly young (i.e. under 30) but the majority of them were women. This provoked some discussion at the morning break as to why young people in our part of the world don't seem to be much interested in taking up science, either as a career or a hobby.

Dave Gault presented the IOTA-VTI for those who hadn't yet had a chance to meet it in person. This video time inserter, developed by Dave Gault and Tony Barry and launched mid-2011, fills the hole left by the

All photos should be credited to Graham Blow.

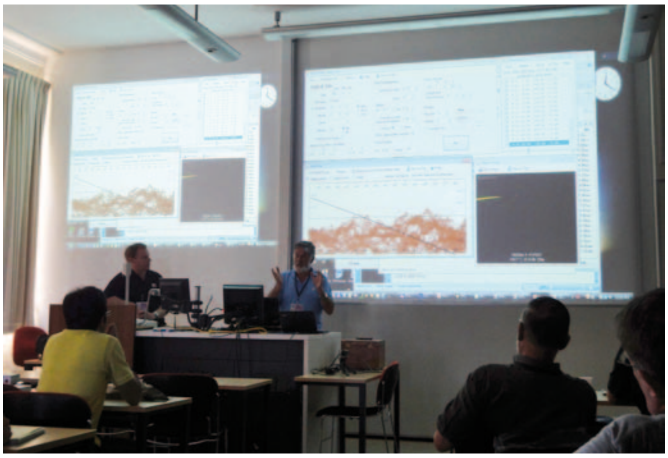
Participants at TTSO6 (Left to Right)

Back Row: John Newman, Dave Gault, John Broughton, Sandor Galos, George Smith, Dennis Lowe, Peter Anderson, Darren Corbett, Colin Bembrick, Andrew Bromage, Terry Butt, Jonathan Bradshaw, Mohammad Mirbagheri
Centre: Jim Blanksby, Tony Barry, Dave Herald, Albert Brakel, Jacquie Milner, Diane Hughes, Steve Kerr, Greg Bolt
Front: John Hughes
Not present: Chris Douglass, Jeff Byron, Adrian Saw, Graham Blow (Photographer)

John Broughton assembles his 10″ f/4 Occultoscope.

John Broughton's partially assembled 10″ f/4 Occultoscope. The scope weighs only 10kg including the mirror, and two can be packed into an ordinary suitcase for ease of travel.

Dave Herald discusses results from the occultation by binary asteroid (90) Antiope.



Dave Herald discusses the analysis of Baily's Beads events at Total Solar Eclipses.

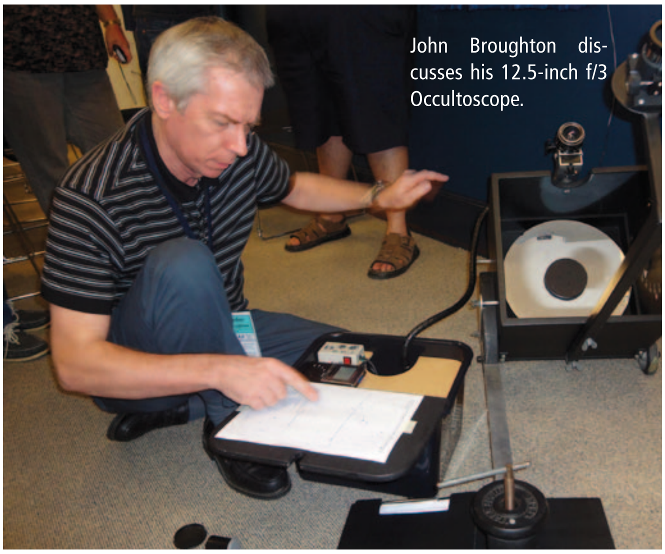
Jim Blanksby (left) and Jonathan Bradshaw discuss details of video observing. Note the GSTAR-EX video camera on the table at left relaying pictures of the room to the laptop.

withdrawal of the KIWI-OSD from the market several years ago. Dave also presented a new tool for visual observers, the GPS-ABC, which can provide a high pitched beep generated by a GPS signal. This is currently an open source do-it-yourself kit, with Dave providing all the documentation for you to build your own. (See: http://www.youtube.com/watch?v=adeX3HTqWCk)

Brian Loader joined us via Skype from New Zealand as well to talk about the value of lunar occultations of double stars and how it is now possible to analyse the magnitude of a star's components with the latest version of LiMovie. Then Dave Herald encouraged us to head to the edges of the path of totality for the upcoming total solar eclipse in far north Queensland to observe and record Baily's Beads, which can aid in the long period assessment of changes in the diameter of the Sun.

After a break for lunch I gave a brief talk on the progress of the Video Occultation Manual which I have been endeavouring to compile during the last two years. Its purpose is to help new observers come to grips with the techniques and technology required to capture occultations on video. This document is still a work in progress and copies of the current version were on hand for people to view and give feedback on. Then we had the "Occultation Clinic", which was an informal session to allow participants to seek help for particular issues they may be having, as well as to get a closer look at the new equipment that had been presented during the meeting. John Broughton's lightweight 12.5" f/3 telescope attracted a lot of attention as did his two portable 10" f/4 telescopes modified for easy pre-pointing. These latter weigh only 10kg each (including mirrors) and both can be carried in the one suitcase for ease of travel.

The day ended with Jonathan Bradshaw pondering the possibility of using a photometer for occultation work and Dave Herald summarising some of the problems that arose from the spectacular results of the 2011 July 19 (90) Antiope binary asteroid event in the US last year.



John Broughton discusses his 12.5-inch f/3 Occultoscope.

Fifty-six reports were received for this one event, and a detailed profile of the two asteroid components was able to be generated. There were lessons there for us all to take on board in order to achieve the highest quality data capture in relation to time stamping the video footage and camera settings in any situation.

At the end of the day the twenty-four participants agreed that it would be useful to continue the symposiums in the future. The next symposium, TTSO7, will be held at the RASNZ annual conference in Invercargill, New Zealand in May 2013.

Journal for Occultation Astronomy

An unexpected grazing occultation

Dietmar Büttner, Germany

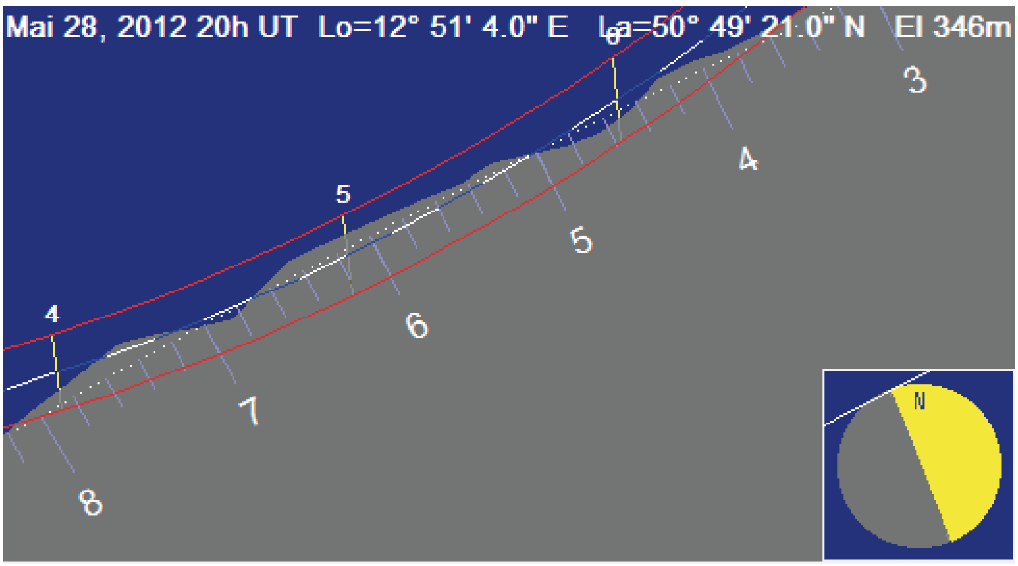
I've been an active occultation observer since 1978.

During the last few years my astronomical focus went more to lunar observing, and I observed occultations only now and then.

On the evening of 2012 May 28 (Whit Monday) I was just making a sketch of an obvious sunlit region in the shadow filled crater Maginus using my 100 mm refractor from my home in Chemnitz (Germany). At about 22:00 Central European Summertime I suddenly got the inspiration to have a look at the lunar cusps. This was purely for the curiosity to see if there was anything interesting, because I had the intention to draw the cusps later. (By the way, drawing the lunar cusps is one of the topics of my regular lunar observations. This has a relation to my former MOONLIMB project for deriving lunar limb profiles from occultation observations.) Only a little bit away from the earthshine lit northern lunar limb I detected a fairly bright star, which seemed to be occulted possibly during the next few minutes. Quickly I got my stop watch. Only about one minute or so after being back at the telescope I saw the first disappearance. Fine. Twelve seconds later a reappearance. Wow. Further 20 seconds later another disappearance. And so on. A real grazing occultation! I saw three disappearances and the three belonging reappearances at the dark limb. Finally, I got an additional short gradual blink. All together seven contacts within 2 minutes.

What is so special with this event?

Firstly, I didn't know about this graze before. My regular occultation predictions for a telescope diameter of 10 cm made with the program OCCULT didn't contain that event for the star XZ 15679 = SAO 118319 with 7.8^{m} (vis). Only, when I moved the magnitude limit by 1 mag to the fainter after the observation, OCCULT put out that event. It's remarkable, that I looked at the cusps by pure inspiration just at the right time. Otherwise, I never would have learned about that event.



Secondly, the graze path just crossed my home. Such a thing is seldom, but happens now and then. During my career of watching occultations already lasting 34 years this was the fourth graze which I observed successfully from my home observatory. On this evening I asked myself, why to setup any distant station in the field for a graze? (As I've done in the past too, and as I will do in the future again.). One has only to wait long enough …

Thirdly, the sky remained clear in the few minutes around the graze. Originally, I was less motivated to set up my telescope on that evening, because, there was a quickly changing cloud coverage and I was rather tired too. Of course, this quite unexpected grazing occultation was a fine present to me and caused a revival in my interest for occultations. See the attached prediction profile from GRZAEPREP by Eberhard Riedel as well as the reduction profile from OCCULT by David Herald. The crosses mark my observations plotted against the high resolution limb profile from Kaguya data. My observations fit very well with the predicted profile.

Shown left is the reduction profile from OCCULT by David Herald (high resolution limb profile from Kaguya data, axis angle reversed !) as well as the prediction profile for my observing location from GRAZPREP by Eberhard Riedel (low resolution Kaguya data). The crosses on the reduction plot mark my observations which fit very well with the predicted GRAZPREP profile.

"No surprise event for GRAZPREP-users"

This nice article by Dietmar Büttner revealed one important aspect to me as the author of GRAZPREP. Actually the event that came over Dietmar by surprise WAS predicted within the grazig occultation files ready for download via the IOTA/ES server. Dietmar found it there only after the event had happened. Out of the complete list GRAZPREP easily allows to filter out any number of events best suited to any observer in regard of travel distance and ease of observation. These selected events can be saved in subset files which allow a good and quick overview of upcoming events.

Other than before observers interested in grazing occultations have to create their own list of events. GRAZPREP does this with somewhat more control than OCCULT that did not reveal this event with its normal setting as Dietmar pointd out. Both programs have to be used properly of course. Concerning GRAZPREP serving as a preparation tool for grazes more information will have to be supplied. The next issue of the JOA will present GRAZPREP in more detail.

Eberhard Riedel

Venus-Transit from Iran – Reporting Program:

This program was held on 2012/6/6 in Park Moallem of Ardabil . Weather was quite smooth. The transition program was implemented in simple projects. It was expressed in the beauty of Astronomy to the people. Amateur and professional astronomical in this program were present. The program from 7.5 to 10 hours of the morning to the time Iran was held. Only the third and fourth of our region was visible. Behind the filter the sun's sunspot observations were beautiful. This transition will end up with observation and photography. Transit of Venus will not be repeated up to 105 years.

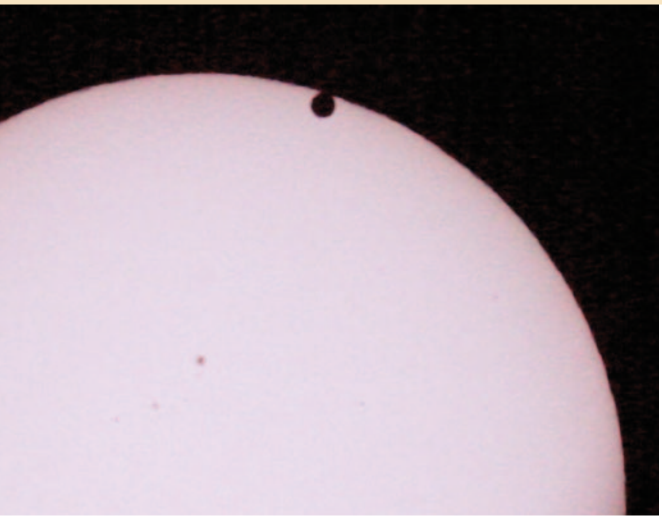
Description transits of Venus in Ardebil:

- Middle Passage: 6:1:55 „
- End of the third pass: 9:7:3 „in the collision angle: 292 degrees
- Through the end of the quarter: 09:24:37 „in the collision angle: 289 degrees
- Ardebil longitude 48 degrees 18 minutes
- Latitude: 38 degrees and 15 minutes

Of all the friends who helped us in this program, we thanks.

Astronomical Society of the boundless universe (Sabalansky) Iran-Ardabil

www.sabalansky.com



Journal for
Occultation Astronomy

On the application of 3D asteroid models to occultation work

Mike Kretlow, Hamburg · IOTA-ES · mike@sky-lab.net

Photometry is one of the most important remote sensing techniques in order to get information about basic physical properties of asteroids. In the past decade the inversion of asteroid light curves was successfully applied to many asteroids and has provided shape models (3D) for currently about 200 asteroids. While a successful observed occultation led to a projection of the asteroid's shape on the fundamental plane for one moment (a so-called profile), the light curve inversion gives us a complete 3D model of the physical object (Fig. 1), but without an information about the absolute dimensions (size in km). Obviously, the occultation method can be used to a) check the reliability of the inversion result and b) as constrain during the inversion process itself (Durech et al., 2011)

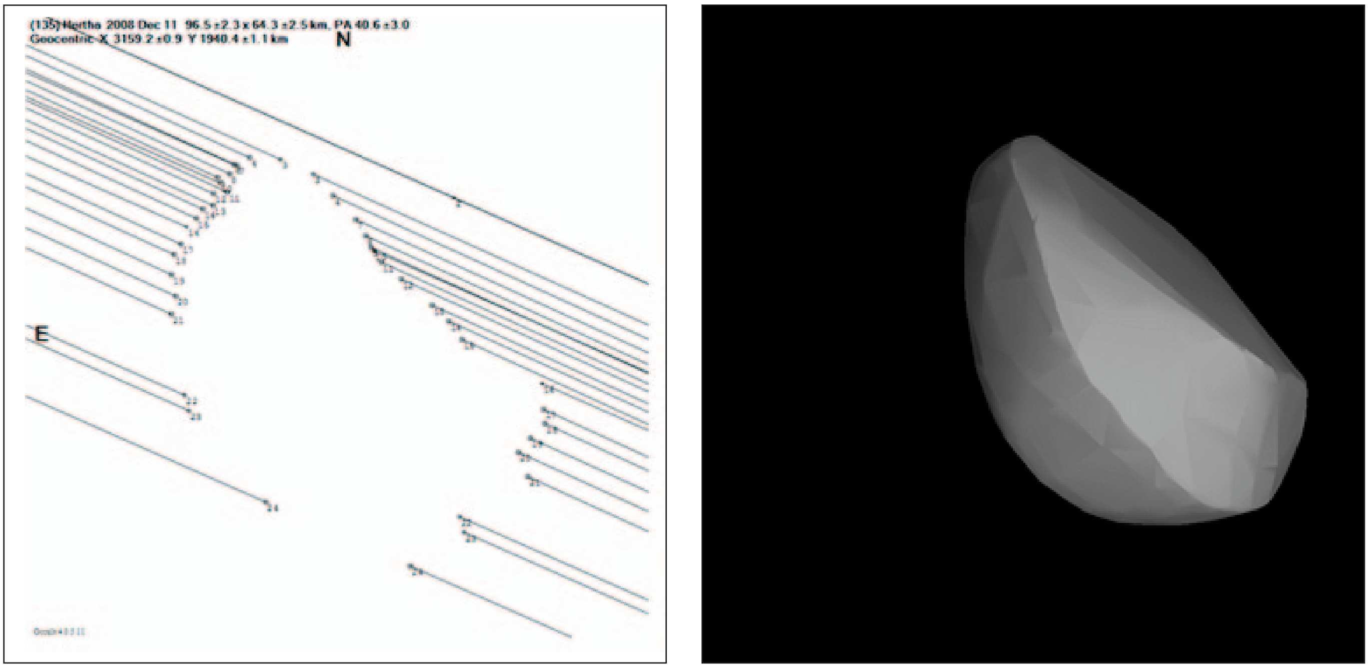


Fig. 1 The occultation of HIP 13021 by (135) Hertha on 2008-12-11 was well observed in the US. On the left side the shape profile on the fundamental plane is outlined from the occultation chords. The right side shows the DAMIT 3D model as seen from the Earth for the time of occultation (by Durech).

In this paper I do not go into the light curve inversion method itself, i.e. deriving 3D shape models from observed light curves. The method is described in Kaasalainen et al. (2002) and papers cited there. Rather, it is shown, that just using existing shape models helps to understand and prepare occultations by these objects and -btw- is also helpful to prepare light curve observations runs.

The main source for these asteroid models is DAMIT (Database of Asteroid Models from Inversion Techniques). DAMIT is a database of asteroid shape models which is operated by The Astronomical Institute of the Charles University in Prague, Czech Republic (Durech et al., 2010).

The web frontend provides an easy access to the data. You can display and download rotational parameters, observed light curves and shape models derived from light curve inversions plus associated information like references, light curve fit results etc. You can even dump the whole database, giving you the possibility to use the data in your own research and programs.

The shape model is provided in a proprietary format (an easy to code facet-vertex-mesh, see below) and meanwhile also in the Wavefront .obj 3D geometry definition file format which can be read and visualized by many model viewer and scientific plotting programs. Even smart phone apps are available to display this .obj models.

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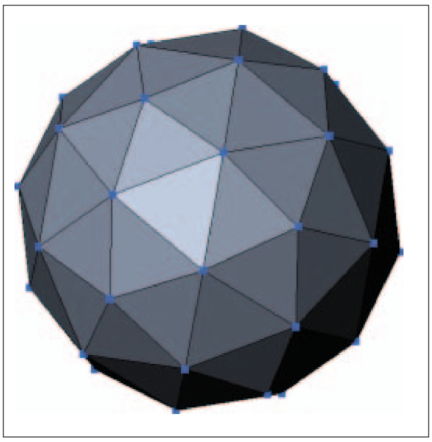


Fig. 2 Representing a body by a triangle mesh (blender.org)

Basically, the object is represented by a mesh of triangles, the small surfaces build from a triangle are called facet, each point of the triangle is called vertex and is represented by a 3D vector in a planetocentric coordinate system (Fig.2).

In simple words, the disc integrated brightness of the asteroid for a time t is computed by applying a reflection / scattering law (here: Lambert's law) to each facet considering the perspective geometry (angle of incidence and viewpoint) and the phase angle function. The summation over all facets visible to the observer for the given time t leads to the relative (and usually normalized) brightness.

While the DAMIT website offers also some C and Fortran programs for processing the data, I decided to implement this algorithms into my own software project which I started a while ago. Furthermore the resulting code can be used in another project, i.e. an Occultation Reports Database[1], automatically providing the perspective view on the asteroids model for the time of a successful observed occultation. Python[2] as programming language was chosen because a lot of scientific grade modules (like scipy and matplotlib) are available, thus avoiding to spend time with programming basic routines, and a lot of graphic packages (like OpenGL) and GUI toolkits are also available or even part of the language standard[3].

As a first step, all data were parsed into a SQLite[4] DB, to provide an easy access from within the software. Secondly a script was written which reads all light curves from DAMIT which were used to derive the 3D model of a specific asteroid[5]. For all observed light curves corresponding synthetic light curves are computed, to verify the result of the light curve inversion. Fig. 3 outlines the result for one of these observed nights. It is also possible to predict and plot the light curve for an arbitrary date (Fig. 4). Currently in progress is to put this code into a GUI based program which allows to handle with observed and computed light curves and to display the 3D model in different perspectives including the resulting light curves. Aim of this paper was to give the reader an idea about how the results of asteroidal occultation observations and light curve inversion can support each other.

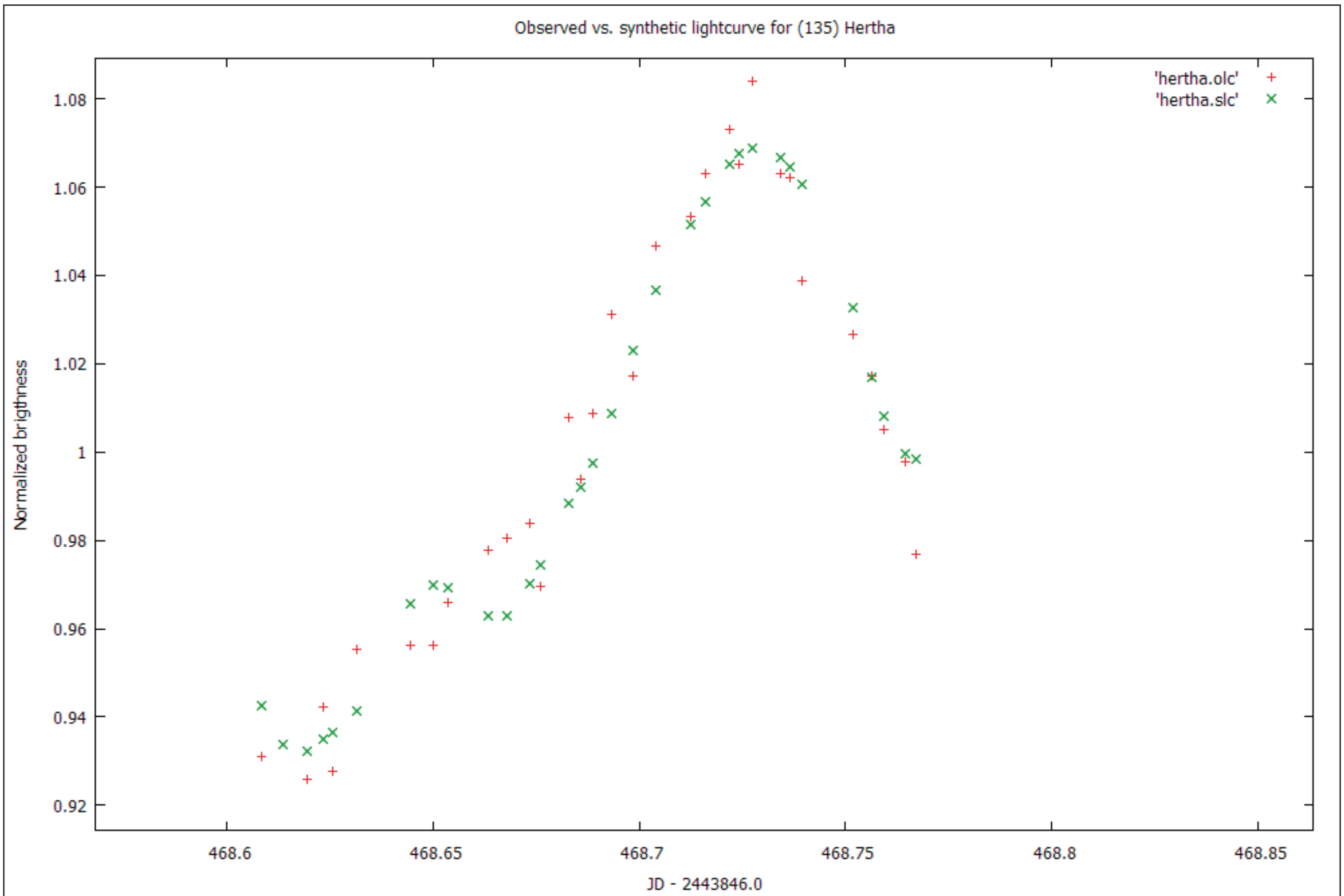


Fig. 3 Comparison between an observed light curve (red) and the synthetic light curve derived from the shape model (green) for (135) Hertha.

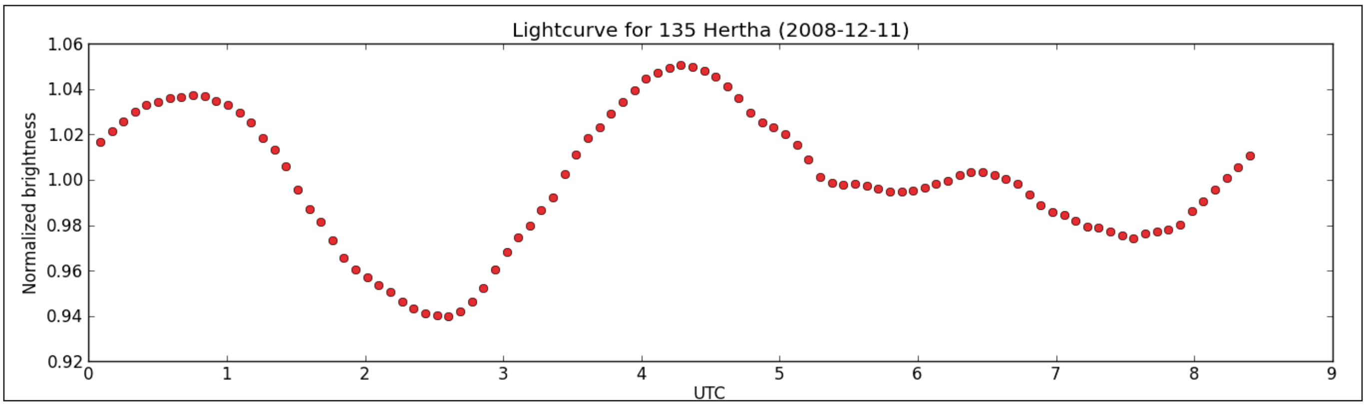
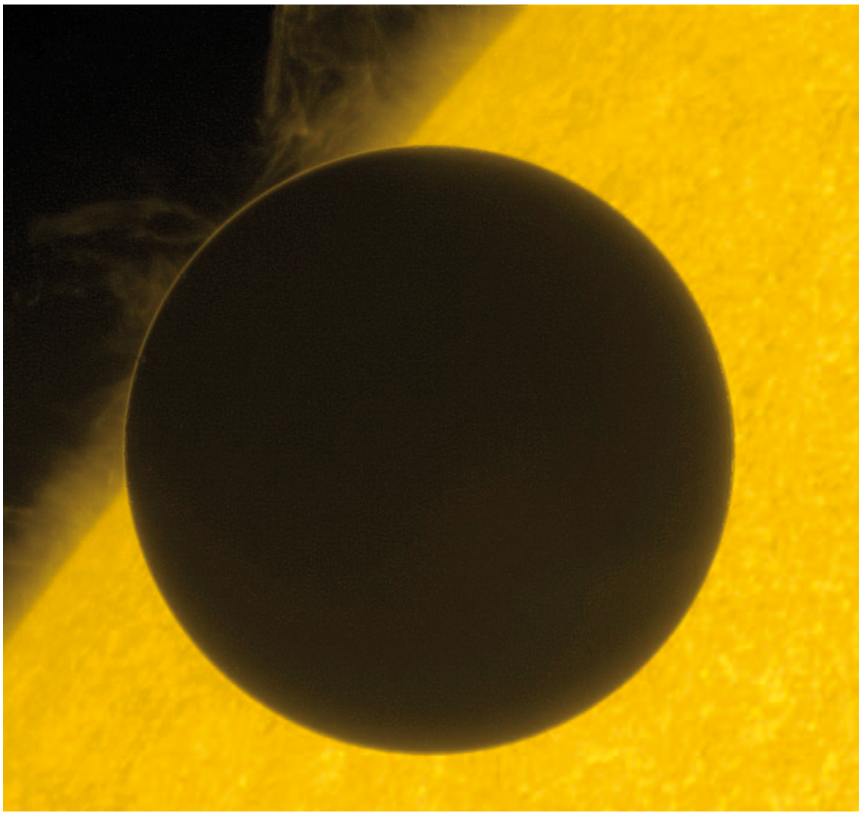


Fig. 4 Predicted light curve for (135) Hertha for the occultation shown in Fig. 1. Observed occultation time was around 07:44 UTC.

References:

Durech et al., 2010: http://cdsads.u-strasbg.fr/abs/2010A%26A...513A..46D
Durech et al., 2011: http://arxiv.org/pdf/1104.4227v1.pdf
Kasaaleinen et al., 2003: Asteroid Models from Disk-integrated Data. In Asteroids III.

1 This paper is based on a presentation given at the annual German minor planets meeting in Berlin, June 2012
2 http://astro.troja.mff.cuni.cz/projects/asteroids3D
3 http://people.sc.fsu.edu/~jburkardt/txt/obj_format.txt
4 http://sky-lab.net/occrep/
5 http://www.python.org
6 Tkinter is the standard GUI toolkit of Python.
7 http://www.sqlite.org/
8 Similar to lcgenerator.c which is provided by Durech / DAMIT.



Venus at the Edge

Image Credit: NAOJ, JAXA, NASA, Lockheed Martin

Explanation:

As its June 6 2012 transit begins Earth's sister planet crosses the edge of the Sun in this stunning view from the Hinode spacecraft. The timing of limb crossings during the rare transits was used historically to triangulate the distance to Venus and determine a value for the Earth-Sun distance called the astronomical unit. Still, modern space-based views like this one show the event against an evocative backdrop of the turbulent solar surface with prominences lofted above the Sun's edge by twisting magnetic fields. Remarkably, the thin ring of light seen surrounding the planet's dark silhouette is sunlight refracted by Venus' thick atmosphere.

Credit: Astronomy Picture of the Day, 2012 June 9

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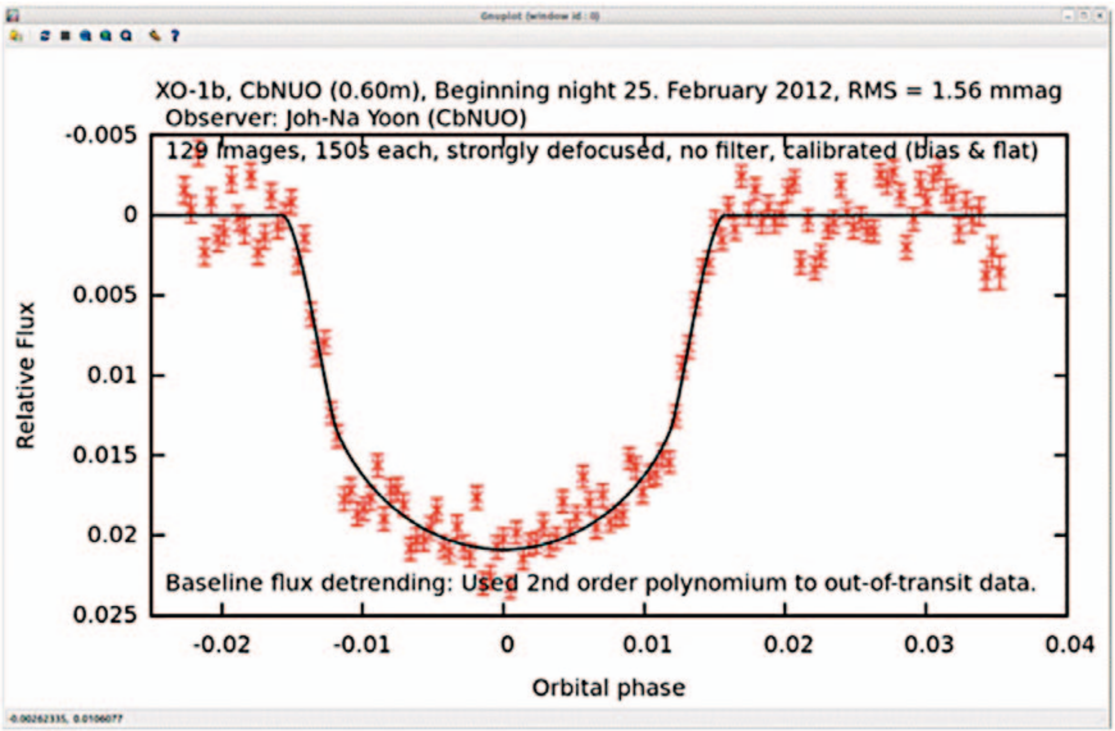
Call for Observations…

Dr. Tobias Cornelius Hinse

…is currently a post-doc at the Korea Astronomy and Space Science Institute in Daejeon South Korea. His research interests are within solar system small body dynamics, celestial mechanics and extra-solar planets. Since 2008 he has specialised himself on the field of transiting extra solar planets and would like to propose the following idea to interested people: Would you be interested in recording light-curves of transiting planets? Here in Korea they applied the technique of heavy defocusing using a 60cm backyard telescope (bad technical condition with bad mirror reflectance and bad weather condition). Defocusing the telescope and observing ~12th mag objects resulted in several surprisingly good light curves. He attached an example light curve with the telescope in defocus mode while observing the transiting planet XO-1b from South Korea. Similar results (or even better) are expected to be obtained for similar



southern hemisphere targets. The defocus technique enables to expose the same (bright) target for a longer time, typically on the order of 120s, without saturating the CCD. This increases the S/N since more photons are collected. The advantage is that pointing errors will be less significant and other systematics minimised. However, it requires that the telescope can still guide while being defocused. Typical observing times are around 4 hours non-stop. To carry out a light curve analysis (in combination with stellar evolution models) one would need 3-4 complete light-curves in a given filter. The data reduction and analysis can be done by him and colleagues here at KASI. A complete analysis will then appear in a peer-reviewed journal (AJ or similar) which will include interested members too! He is also involved in the ground-based detection of circumbinary extrasolar planets by the use of the so-called light-travel time effect. This is a newly emerging subject within the science of extrasolar planets. Such additional objects are called circumbinary companions. The technique uses measurements of the times of minimum light of the binary primary eclipse to infer the existence of additional bodies orbiting the two components. For compact binaries

the binary-companion system will orbit a common centre of mass. Hence at times the binary will be relatively close to the observer, at other times it will be more distant. This is the very essence of the light-travel time effect and resembles the pectroscopic

radial-velocity technique which also infers the presence of extrasolar planets by the wobbling motion of the host star. However, here they use photometry which is a relatively cheaper observing technique.

To obtain reliable timing data with good precision the primary eclipse should be well sampled and the photometry should be of good quality in overall. At the moment several systems need ground-based follow-up observations for further characterisation and a typical nightly observing run will last for 3-4 hours.

However, at this stage he would like to ask whether somebody has interest in this idea.

Please do answer to:

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IOTA's Mission

The International Occultation Timing Association, Inc. was established to encourage and facilitate the observation of occultations and eclipses. It provides predictions for grazing occultations of stars by the Moon and predictions for occultations of stars by asteroids and planets, information on observing equipment and techniques, and reports to the members of observations made.

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