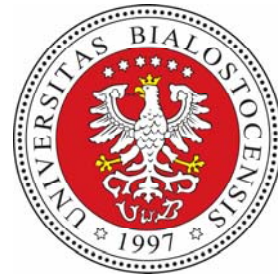


Polskie  
Towarzystwo  
Miłośników  
Astronomii

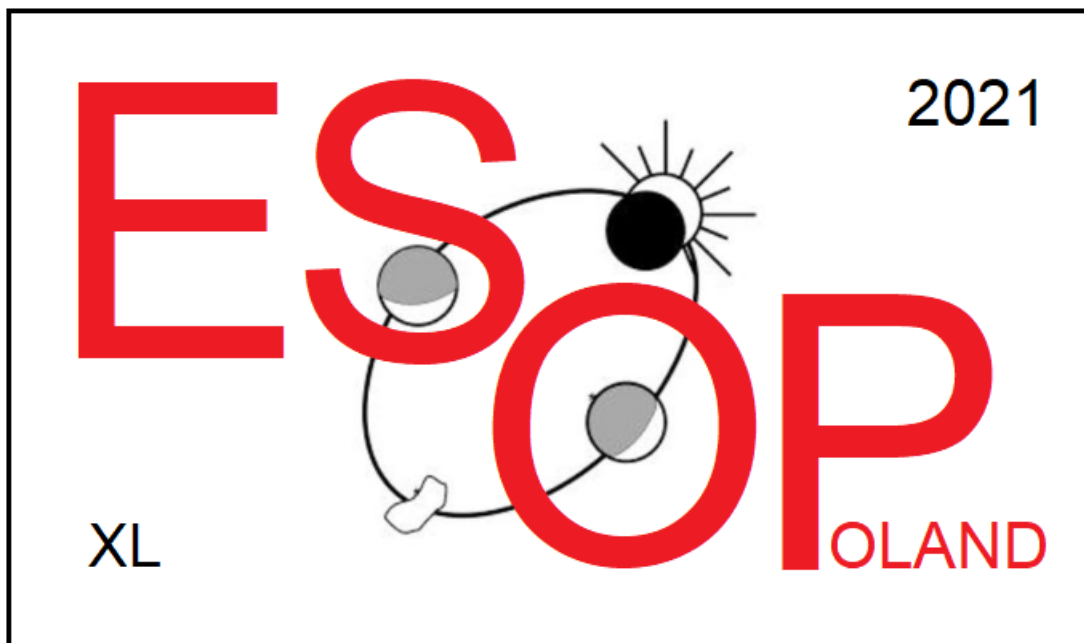


# ESOP XL

40<sup>th</sup> European Symposium on Occultation Projects

Białystok, Poland

August 27-31, 2021



# PROGRAM

## FRIDAY, August 27

17:00 - 20:00

registration desk open in Esperanto Cafe (Kosciuszko Square 10)

19:00 - 22:00

Barbecue - snack and drinks in Esperanto Cafe (Kosciuszko Square 10)

## SATURDAY, August 28

09:00 - 09:15 **OPENING CEREMONY**

### **LECTURES 1 – OBSERVATIONS (09:15 – 10:40)**

09:15 - 09:30

Oliver Klös - Lunar Occultation of HIP 36603, 2021 Feb 23 - a Double Star Discovery?

09:30 - 10:00

Jiří Kubánek - The occultation by asteroid 1997 WP21 and other Czech observations

10:00 - 10:25

Bernd Gährken - Graze of Asellus Borealis on Sep 14, 2020

10:25 - 10:40

Wojciech Burzyński - Daylight grazing occultation of Asellus Borealis on Sep 14, 2020

10:40 - 11:00 coffee break + posters

## **LECTURES 2 – DATA ANALYSIS (11:00 – 12:30)**

11:00 - 11:25

João Ferreira - Asteroid astrometry by stellar occultations: statistics on accuracy from orbital fitting

11:25 - 11:50

Marek Zawilski - The role of historical occultation observations

11:50 - 12:10

Karolina Dziadura - Stellar occultation method of asteroids size and orbit determination

12:10 - 12:30 (ZOOM)

Djounai Baba Aissa - Analysis of a new stellar occultation by asteroids among Algeria territory

12:30 - 13:30

common photography and observatory guided tour

13:30 - 14:30 lunch in University Cultural Center

## **LECTURES 3 – DATA ANALYSIS 2 (14:30 – 16:10)**

14:30 - 14:50 (ZOOM)

Robert Purvinskis - GoeEcl: an update to a deep occultation event search

14:50 - 15:15 (ZOOM)

Altair R. Gomes Júnior - The python library SORA: Stellar Occultation Reduction and Analysis

15:15 - 15:40 (ZOOM)

Flavia L. Rommel - Stellar occultations by 2002 MS4: preliminary results

15:40 - 16:10 (ZOOM)

David Dunham - Accurate NEO Orbits from Occultation Observations

16:10 - 16:30

coffee break + posters

16:30 - 18:00

**IOTA/ES General Assembly**

19:00 - 22:30

Social Dinner - Esperanto Cafe (Kosciuszko Square 10)

## **SUNDAY, August 29**

### **LECTURES 4 – OBSERVATIONS 2 (09:00 – 10:20)**

09:00 – 09:35

Eberhard Bredner – Max and Moritz observe minor planets

09:35 – 10:10 (ZOOM)

Costantino Sigismondi – Occultations of Antares by the Vatican Obelisk observed from the meridian line of St. Peter's square

10:10 – 10:20 (ZOOM)

Carles Schnabel – The observation campaign for the stellar occultation by (15094) Polymele in Spain in behalf of the NASA's Lucy mission

10:20- 10:40

coffee break + posters

### **LECTURES 5 – EQUIPMENT (10:40 – 12:20)**

10:40 - 11:00

Anna Marciniak - Upgrade of the photometric telescope in Borowiec for occultation work

11:00 - 11:30 (ZOOM)

Andreas Schweizer - Current state of the DVTI Camera Project

11:30 - 11:55

Konrad Guhl - The expedition telescope "M2" - history and observation successes

11:55 - 12:20

Pascal Andre - DIY: make the cheapest and probably the smallest VTI in the world

## **FUTURE ESOP AND CLOSING REMARKS (12:20 – 13:00)**

12:20 - 12:40 (ZOOM)

Pablo Santos-Sanz - The ESOP 2022 in Granada, Spain

12:40 - 13:00

Closing remarks

13:00 - 14:30

lunch in University Cultural Center

## **PRACTICAL WORKSHOPS (14:30 – 18:00)**

14:30 - 16:00 (LIVE SHOW+ ZOOM)

Pascal Andre - making the cheapest and probably the smallest VTI in the world

16:00 - 16:20

coffee break + posters

16:20 - 18:00 (LIVE SHOW + ZOOM)

Konrad Guhl - M2 telescope assembling and deassembling

14:30 - 18:00 (NOT TRANSMITTED BY ZOOM)

SEXTA Test Bench - Latency test of camera setup for ESOP participants

## LADIES PROGRAM

### **Saturday, August 28 (09:15 - 17:00)**

09:15 - 10:00 – trip to Czarna Wieś Kościelna (Trail of Folk Crafts), 26 km

10:00 - 10:30 – blacksmith (5 PLN)

10:40 - 11:00 – potter: guided tour + pottery shop

11:10 - 12:10 – walk around Czapielówka Reservoir

12:30 - 13:30 – lunch (Bar Max, Czarna Białostocka)

13:30 - 14:00 – return trip to Białystok

14:15 - 16:00 – jewelry making workshop

16:00 - 17:00 – Planty Park & ZOO walk

*Please take some money in PLN with you – for lunches, shopping and workshops.  
Please also take rain clothes and umbrellas. If there is heavy rain, plans may be changed :)*

### **Saturday, August 29 (09:00 - 17:00)**

09:00 - 10:30 – trip to "Ziołowy Zakątek" („Herbal Nook”), 83 km

10:30 - 11:30 – Herbal Nook guided tour (18 PLN)

11:30 - 12:15 – tea and herbal workshops (15 PLN)

12:30 - 13:30 – lunch in Herbal Nook

13:30 - 15:00 – return trip to Białystok

15:00 - 17:00 – shopping time in Alfa Shopping Mall

*Please take some money in PLN with you – for lunches, shopping and workshops.  
Please also take rain clothes and umbrellas. If there is heavy rain, plans may be changed :)*

## ADDITIONAL TRIPS

### Monday, August (08:50 - 16:15)

08:50 – bus trip to Tykocin, meeting point near Branicki’s Palace Gate  
09:30 – Tykocin guided tour: church, the main square, Czarniecki’s monument, synagogue  
10:00 – Water Tram Trip on Narew river  
11:00 – short break for a beer/coffee/tea/ ice cream - Alumnat Hotel  
12:00 – Tykocin Castle guided tour  
13:15 – Museum of Polish Arms in Kiermusy village  
14:30 – lunch in Kiermusy „Rome” Manor  
15:30 – return trip to Białystok  
16:15 – Białystok

*Please take some money in PLN with you – for snacks and souvenirs  
Please also take rain clothes and umbrellas. If there is heavy rain, plans may be changed :)*

### Tuesday, August 31 (08:30 - 17:30)

08:30 – meeting point near Branicki’s Palace Gate  
Białystok guided tour - Branicki’s Palace, souvenir shop, Cathedral Church, Town Hall, Zamenhof’s Monument, St. Nikolai Orthodox Cathedral Church  
10:00 – bus trip to Supraśl  
10:30 – Museum of Orthodox Icons  
11:30 – Supraśl bus tour  
12:00 – Silvarium Forest Garden - gallery and tour of the area  
13:30 – trip to Kruszyniany – Tatar village  
14:00 – Kruszyniany - wooden mosque, old muslim cemetery  
15:00 – lunch in Gospoda w Chlewie („Pigsty Inn”)  
16:30 – return trip to Białystok  
17:30 – Białystok

*Please take some money in PLN with you – for snacks and souvenirs  
Please also take rain clothes and umbrellas. If there is heavy rain, plans may be changed :)*

# ABSTRACTS

## **Lunar Occultation of HIP 36603, 2021 Feb 23 - A Double Star Discovery?**

*Oliver Klös*

On 2021 Feb 23 I tried to record several lunar occultations. Not an easy task with a nearly full moon. HIP 36603 (7.6 mag) took my attention at once during the recording. It seems there was a very faint step event of unusual long duration. Was it a trick of my senses or a real event? The catalogues didn't list this star as a double.

A first analysis with Tangra showed the step as well. An advanced analysis was made with Limovie and a double star report was sent to IOTA's Double Star Coordinator, Martin Unwin. There is no confirmation of the double star discovery yet.

Another lunar occultation of this star will not be observable before late 2026.

I want to thank Alex Pratt (BAA, IOTA/ES) for his assistance with the analysis of the event with Limovie.

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## **The occultation by asteroid 1997 WP21 and other Czech observations**

*Jiří Kubánek*

On 14 February 2021 two observers in Central Europe, each of them recorded 3 positive events. The occultation by minor planet 1997 WP21 was at first glance common. After the processing of both results together, the occultation became interesting. The time difference between the observations was 6 seconds. A possible explanation is that the asteroid has a moon.



## **Graze of Asellus Borealis on Sep 14, 2020**

*Bernd Gährken*

On September 14th, 2020 there was a grazing eclipse of the 4.7 mag star Asellus Borealis. It is one of the brighter stars in the constellation Cancer. It is located directly north of the M44. The geometry was perfect at 14. Sept. 2020. The moon was a narrow crescent just a few days from the new moon. It should be about 30 degrees high in the morning sky when it is occulted.

The lecture provides a report on the successful observation in southwest Germany.

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## **Daylight grazing occultation of Asellus Borealis on Sep 14, 2020**

*Wojciech Burzyński*

While the geometry of the event was very good in Western Europe, in north-eastern Poland the Sun was already quite high above the horizon. Despite the high brightness of the sky background, the event was registered. It was my first lunar grazing occultation observed during the day. The large 30-cm telescope and the sensitive Watec-910HX camera contributed to the success.

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## **Asteroid astrometry by stellar occultations: statistics on accuracy from orbital fitting**

*João Ferreira*

### **Context**

Stellar occultations by small bodies of the Solar System are a powerful way of investigating physical properties of objects that are in general too far and small to offer details at telescopes on Earth. Revived by the publication of the Gaia data releases, this technique permits not only the

determination of asteroid size and shape, but also the retrieval of additional very accurate astrometry, with a possible relevant impact on the study of dynamical properties. In previous works, we presented the impact of the Gaia Data Release 1 on the precision of occultation astrometry, and the possible performances of a single telescope used to systematically collect asteroid astrometry. In recent times, a new error model for occultation astrometry was also implemented to better describe the uncertainties specific to this technique, and the data reduction was refined.

## **Aims**

Here we explore in more details the improvement in performance brought by Gaia DR2 and EDR3, exploited jointly to the new occultation error model and the new astrometry. Our goal is to verify that the extreme quality of DR2, in particular, brings a sensible progress in the exploitation of occultation astrometry.

## **Methods**

We proceed by accurate orbit computation of occultation data, alone or joined to the other available ground-based observations.

## **Results and Discussion**

We find that Gaia DR2 brings a noticeable improvement to the accuracy of occultation data. This is particularly visible when occultations alone are used, resulting in very good orbits for a large fraction of objects. The joint use of archival data and occultations remains more challenging as the higher uncertainties and systematic errors of existing data have the tendency to deteriorate the results obtained by occultations alone.

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## ***The role of historical occultation observations***

*Marek Zawilski*

Observations of solar eclipses made over the past many years and their effects can be analyzed in several ways:

- ❖ General development of astronomical knowledge
- ❖ Recognition of the Sun's structure
- ❖ Dating historical events
- ❖ Social and cultural aspects
- ❖ Investigation of rotation of the Earth and of the orbital movement of the Moon

At present, the latter effect seems to be of greatest importance to us, with solar eclipses being treated as one of the occultation phenomena.

In the period of the development of modern celestial mechanics, historical observations of eclipses made it possible, inter alia, to testing the theory of the motion of the Moon and the Sun. As it turned out, however, it was also necessary to take into account the non-uniformity of the Earth's rotation, and in the theory of the Moon's movement, its so-called secular acceleration.

Attempts to solve these problems with varying degrees of success have been observed especially since the 1970s (R.R. Newton, F.R. Stephenson), and subsequent in-depth analyzes were carried out until 2020 (L.V.Morrison *et al.*). They were possible thanks to determination of reliable value of the secular acceleration of the Moon (mainly thanks to the Apollo missions), the development of improved theories of its motion and the completion and verification of the set of historical observations.

The use of this rich set of historical observations of solar eclipses (together with some other lunar occultations) allowed for a fairly reliable determination of the range of the DeltaT curve values for each of the observed phenomena (according to their source records), and hence the approximation of this continuous curve for the period from around 700 BC till present years. The final result shows the strong influence of non-tidal factors in the rotation of the Earth and the periodic fluctuations in the length of the day.

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## **Stellar occultation method of asteroids size and orbit determination**

*Karolina Dziadura*

Stellar occultations can be used in various ways, which are size determination, model verification, rings and satellites detection and precise astrometry measurements which are used for Yarkovsky effect determination.

The main goal of this work was to create an algorithm for the size determination of the asteroids based on their occultations and to verify the model of selected asteroids. Models were previously determined from the light curves. If there are enough observations across the shadow path, the shape of the models of asteroids derived from light curves can be established. I will present the method and results for five asteroids along with their uncertainties, which take into account the uncertainty of observation time. I also determined the maximum and the effective diameter for asteroids: (704) Interamnia, (13) Egeria, (14) Irene, (308) Polyxo, and (3) Juno. I will explain how stellar occultation is the cheapest and at the same time the most effective method (after spacecraft measurements) of small bodies size determination.

## **Analysis of a new stellar occultation by asteroids among Algeria territory**

*Djunai Baba Aissa*

From several years and as part of the research that we have developed at the Algiers Observatory, which focuses on the study, and observation of stellar occultations by asteroids, we report our latest results since 2019 until now:

- positive double stellar occultation by asteroid (3200) Phaethon in 15 and 25 October 2019,
  - negative occultation by Hiiaka the satellite of the dwarf planet (136108) Haumea 06.4.2021
  - four missions in 2021 on Algerian territory using 3 Schmidt-Cassegrain telescopes to observe stellar occultations by Near-Earth asteroids.
  - organisation of the 8th and 9th national meetings on occultations on October 27, 2019 and October 24, 2020 in the context of participative astronomy.
- 

## **GoeEcl: an update to a deep occultation event search**

*Robert Purvinskis*

At the previous ESOP, first results of a search for asteroid occultations near the Ecliptic, using fainter stars (fainter than 14th magnitude) in the Gaia DR2 were presented. This search has now been updated and run again a number of times during the past year. The presentation will give an update on progress with a focus on statistics and changes to the search parameters.

The newer data set allowed a lot more statistics to be gathered for a useful time period. The second half of the year (July-December) in particular is interesting, because the southern Milky Way fields (designated 'MW2' in the GOEcl fields) are in the evening sky, near quadrature, and therefore both Milky Way fields are accessible at this time of year. Even at other times of the year, without the 'MW2' fields, it is clear that it is possible to generate several thousand events in a single month. Most of events involve faint stars and small objects, so for a single observer location it is unlikely that a positive observation will result. However another common feature of this prediction set is that multiple events occur for individual objects.

A further feature of the talk will be a short discussion of the prediction of stationary point events, which may be interesting for the detailed observation of small diameter objects.

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## The python library SORA: Stellar Occultation Reduction and Analysis

*Altair R. Gomes Júnior*

With the increase in the number and precision of observed stellar occultations, the demand for a more efficient, precise, organized, and faster procedure of reduction has also increased. In this regard, we developed SORA, an open-source python library with a collection of tools for the users to develop their own method of analysis.

SORA is based on python classes with tools to handle the star, body, observer, and light curve information that can be integrated into a dynamical reduction methodology of the occultation.

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## Stellar occultations by 2002 MS4: preliminary results

*Flavia L. Rommel*

F. L. Rommel<sup>1,2,3</sup>, M. Vara-Lubiano<sup>4</sup>, F. Braga-Ribas<sup>2,1,3</sup>, J. L. Ortiz<sup>4</sup>, R. Vieira-Martins<sup>1,3</sup>, B. Sicardy<sup>5</sup>, J. I. B. Camargo<sup>1,3</sup>, P. Santos-Sanz<sup>4</sup>, B. E. Morgado<sup>5,1,3</sup>, J. Desmars<sup>6,7</sup>, G. Benedetti-Rossi<sup>5,3</sup>, R. Duffard<sup>4</sup>, M. Assafin<sup>8,3</sup>, E. Fernández-Valenzuela<sup>9</sup>, N. Morales<sup>4</sup>, A. R. Gomes-Júnior<sup>10</sup>, G. Margot<sup>2,3</sup>, C. L. Pereira<sup>1,3</sup>, J. Lecacheux<sup>5</sup>, Y. Kilic<sup>11,12</sup>, E. Frappa<sup>13</sup>, M. R. Alarcón<sup>14</sup> and 176 co-authors (observers team).

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<sup>2</sup> Federal University of Technology - Paraná (UTFPR/DAFIS), Rua Sete de Setembro, 3165, Curitiba (PR), Brazil.

<sup>3</sup> Laboratório Interinstitucional de e-Astronomia - LIneA & INCTdo e-Universo, Rua Gal. José Cristino 77, Bairro Imperial de São Cristóvão, Riode Janeiro (RJ), Brazil.

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<sup>8</sup> Observatório do Valongo/UFRJ, Ladeira Pedro Antônio 43, Rio de Janeiro (RJ), Brazil.

<sup>9</sup> Florida Space Institute, University of Central Florida, 12354 Research Parkway, Partnership 1, Orlando, FL, USA.

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<sup>11</sup> Institute of science and technology, Akdeniz University, Antalya, Turkey.

<sup>12</sup> Tübitak National Observatory, Bakirli-tepe mountain, Antalya, Turkey.

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<sup>14</sup> Canary Islands Institute of Astrophysics, Tenerife, Spain.

Trans-Neptunian Objects (TNOs) are small bodies that orbit the Sun with a semi-major axis larger than Neptune's (Jewitt et al. 2008). They are thought to be remnants of the Solar System primordial disk. In this context, they may retain information about the early stages of our planetary system formation and evolution. Stellar occultation is a ground-based technique that has been

presenting exciting advances in the knowledge of Centaurs and TNOs' physical properties (Sicardy et al. 2011; Braga-Ribas et al. 2013; Benedetti-Rossi et al. 2016, 2019; Dias-Oliveira et al. 2017; Ortiz et al. 2012, 2020; Souami et al. 2020; Santos-Sanz et al. 2021) and surrounding structures (Braga-Ribas et al. 2014; Ortiz et al. 2017).

In 2002, Trujillo and Brown discovered the big TNO called 2002 MS<sub>4</sub> with observations from Palomar Observatory. Using thermal measurements made by Spitzer Space Telescope and Herschel Space Observatory, Vilenius et al. 2012 determined an equivalent diameter of 934 +/- 47 km and a geometric albedo at V-band 0.051<sup>-0.022 +0.036</sup>. Due to its size, it is expected that 2002 MS<sub>4</sub> is in hydrostatic equilibrium.

Since 2019, we predicted and observed seven stellar occultations by 2002 MS<sub>4</sub> under the framework of the European Research Council (ERC) Lucky Star project (<https://lesia.obspm.fr/luckystar/index.php>).

The most successful campaign involved 116 telescopes and almost 200 astronomers from Europe, North Africa, and Western Asia on 8 August 2020. This campaign resulted in 61 positive detections well distributed over the shadow path. After an extensive analysis, our preliminary results show a 130 km smaller object than previously published. In addition, we detected two 20 km wide topographic features located in the northernmost region.

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## Accurate NEO Orbits from Occultation Observations

*David Dunham*

Precise orbit determination is very important for planetary defense against Potentially Hazardous Asteroids (PHAs). Orbits of NEOs are generally best improved by radar observations, but these are only possible when the NEO is relatively close to the Earth. A threatening NEO can be out of radar range for decades, during which its orbit might evolve from YORP perturbations and other small non-gravitational forces.

Now that we have precise stellar data from ESA's Gaia mission, observations of occultations of stars by NEOs can provide astrometric points at least as accurate as the size of the NEO as seen from the Earth, normally about a milliarcsecond, or less. Well-observed occultations can also give

information about the size, shape, and multiplicity of the object. For background, past NEO occultations will be described briefly (Eros in 1975, Phaethon in 2019 and 2020). But mainly, the successful observations of the occultations by Apophis this year will be discussed.

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### ***Max and Moritz observe minor planets***

*Eberhard Bredner*



Observing occultations of minor planets in the heart of Europe is a challenge. You always have to fight at two important points.

**FIRST:** Whatever the reason for misinformation may be, the reliance on accurate weather forecasts is a problem.

**SECOND:** Only in rare cases the possible observers are well distributed within the shadow zone and mostly not mobile if the weather does not allow observation at the observer's location.

As a mobile observer, I have therefore composed two observation devices <Max and Moritz> over the years. Max is the major station operated by me, Moritz observes independently after prepointing. My experiences and first results will be presented in the lecture

***Occultations of Antares by the Vatican Obelisk  
observed from the meridian line of St. Peter's square***

Costantino Sigismondi

The meridian transits of Antares with a very low parallax error appear as real occultations lasting 5 m 19 s. They have been audio-recorded from 23 to 31 July 2021, with the star in quadrature, so its aberration in longitude is zero.

An accuracy on the sidereal day of +/- 27 ms has been reached observing the dis-appearance and the re-appearance with a 7x18 mm monocular aimed at a mirror located at the end of the meridian line (Capricorn) of st. Peter's square in the Vatican.

An accuracy of +/-13 arcsec has been reached for the azimuth of the axis of the obelisk seen from the same position.

**Keywords:** Occultations "old style", Positional Astronomy, Stellar Aberration, Azimuth determination

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**Upgrade of the photometric telescope in Borowiec for occultation work**

*Anna Marciniak*

In Spring 2021 we performed an upgrade of the photometric telescope in the Borowiec station near Poznan, Poland. This 40-cm Newtonian owned by our institute has, for more than 20 years, served for photometric studies of asteroids, and gathered thousands of lightcurves. However now, with more usage of robotic and automated telescopes, and wide collaborations for lightcurve studies, we could shift the scope of this instrument to occultation work..

The old SBIG ST7 CCD camera has been replaced with Andor Zyla sCMOS camera, and additional GPS module has been installed for precise timing. As a result, the read-out time has decreased by two orders of a magnitude, and the timing precision has increased substantially.

The talk will present first results of the stellar occultations by asteroids observed with the upgraded instrument.



## **Current state of the DVTI Camera Project**

*Andreas Schweizer*

The goal of the DVTI camera project is to develop a digital video camera targeted mainly at observing stellar occultations.

In this talk, we present the DVTI camera project, especially the current state of the hardware, firmware and software development, and also the remaining steps needed before observers can start buying the camera.

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## **The expedition telescope "M2" - history and observation successes**

*Konrad Guhl*

In 2013, the IOTA/ES acquired a 500/2000mm Dobsonian telescope. The instrument has been converted to an expedition telescope for mobile use and is available to IOTA/ES members.

It has contributed to the exploration of Pluto, Chariklo and Quaoar in 2016, 2 x 2017 and 2019. Construction history and results will be presented. In a workshop the assembly and disassembly will be demonstrated and practiced for observers.

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## **DIY: make the cheapest and probably the smallest VTI in the world**

*Pascal Andre*

The lecture describing idea and implementation of the probably the smallest analog video time inserter, in which the display of the exact time pattern is based on a very small OSD module used in drones or aircraft models.

## **STATIONARY PARTICIPANTS**

- 1. Sven Andersson, Germany**
- 2. Pascal Andre, accompanied by Chantal and Alice, France**
- 3. Maciej Borkowski, Poland**
- 4. Mieczysław Borkowski, Poland**
- 5. Eberhard H. R. Bredner, PhD , Germany**
- 6. Wojciech Burzyński, Poland**
- 7. Daniel Błażewicz, Poland**
- 8. Andreas Dill, Belgium**
- 9. Karolina Dziadura, Poland**
- 10. Chad Ellington, USA**
- 11. João Ferreira, PhD, Portugal**
- 12. Konrad Guhl accompanied by Elke Guhl, Germany**
- 13. Bernd Gährken, Germany**
- 14. Martina Haupt, Germany**
- 15. Maciej Jarmoc, Poland**
- 16. Oliver Klös, Germany**
- 17. Sławomir Kruczkowski, Poland**
- 18. Jiří Kubánek accompanied by Lucie and Simona Kubánková**
- 19. Anna Marciniak, PhD, Poland**
- 20. Marek Nikořajuk, PhD, Poland**
- 21. Andreas Tegtmeier, accompanied by Carmen Tegtmeier, Germany**
- 22. Nikolai Wünsche accompanied by Annette Wünsche, Germany**
- 23. Marek Zawilski, PhD, Poland**
- 24. Olcaytuğ Özgüllü, Turkey**

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25. Jan Maarten Winkel, Netherlands
26. Petr Zeleny, Czechia

# MAPS

