Journal for
Occultation
Astronomy

2016 – 01

INTERNATIONAL OCCULTATION TIMING ASSOCIATION

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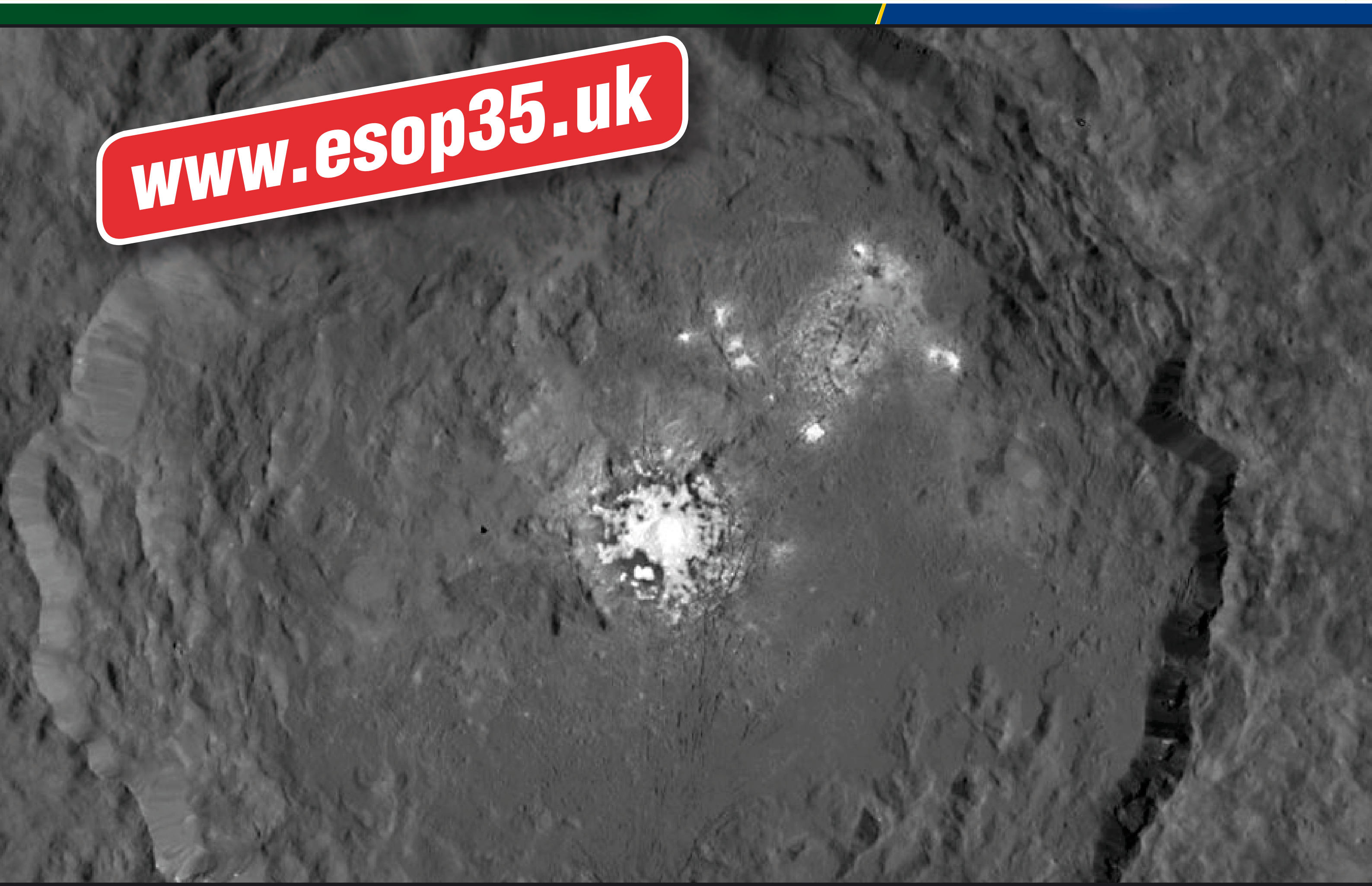

Bright Spots Resolved in Occator Crater on Ceres

Explanation: What created these bright spots on Ceres? The spots were first noted as the robotic Dawn spacecraft approached Ceres, the largest object in the asteroid belt, in February, with the expectation that the mystery would soon be solved in higher resolution images. However, even after Dawn arrived at Ceres in March, the riddle remained. Surprisingly, although images including the featured composite taken in the last month do resolve many details inside Occator crater, they do not resolve the mystery. Another recent clue is that a faint haze develops over the crater's bright spots. Dawn is scheduled to continue to spiral down toward Ceres and scan the dwarf planet in several new ways that, it is hoped, will determine the chemical composition of the region and finally reveal the nature and history of the spots. In several years, after running out of power, Dawn will continue to orbit Ceres indefinitely, becoming an artificial satellite and an enduring monument to human exploration.

Image Credit: NASA, JPL-Caltech, UCLA, MPS/DLR/IDA

Journal for
Occultation Astronomy

Dear reader,

unfortunately a huge gap occurred between the last issue in 2015 und this one.

The explanation for this situation is quite simple: like in the past, there were not enough articles received within this time-gap to produce this issue.

I presume you are using the internet for different kinds of reasons and perhaps for reading and discussing astronomical problems you want to solve. In the case of complex problems you will receive a lot of answers and different opinions and if it is resolved you will work with this result.

And what would happen next?

The result you achieved has been discussed amongst a small group or an online forum.

There might more fellow observers having this kind of problem, unaware of your solution. Now it would be easy to help them too: just publish your result in JOA!

There are a lot more things you could do to help other engaged astronomers: So being a serious astronomer, give a JOA presentation of your astronomical equipment, the subjects you are working on and a data extract. Of course, in general there will always be someone who would like to analyse and work on the data you collected. Acting like this you will get an impression of what can be done with your data and maybe having time, you could assist with the processing.

Klaus-J. Bode

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In this issue:

Writing articles for JOA:

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

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

There are 3 different possibilities for submitting articles:

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

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

txt-files: Details, that should be regarded

- Format-commands are forbidden
- In case of pictures, mark them within the text like <picture001> where they should be positioned

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

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

Sending articles to JOA:

Each country / state has a coordinator who will translate your article to English – if necessary.

In case there is no one (new country) please send a mail to the editorial staff at: **info@occultations.info**

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Journal for Occultation Astronomy

The grazing occultation of Aldebaran on April 21, 2015

Marek Zawilski, Wojciech Burzyński and Karol Wójcicki

Introduction

After 15 years a new series of the lunar occultations of Aldebaran (Alpha Tauri), a red giant, started on January 29, 2015. On February 25 and March 25, 2015 two subsequent grazing occultations of this star occurred in Canada and north-west USA and in central Asia, respectively.

In the evening of April 21, a next graze at the southern lunar limb could be visible in north-east Poland, Belarus and northern Ukraine (Fig.1). In Poland, the event took place shortly after sunset, in the still bright sky, fortunately at the altitude of more than 20 degrees, almost exactly at the southern cusp of the lunar crescent.

This occultation was a chance to perform a valuable observation, for the first time since April 28,1998 when last graze of Aldebaran at the northern lunar limb was observed in Poland, on the outskirts of Lodz. However, the prediction of the lunar profile appeared that time very inaccurate (Watts data), so that about one third of the organized stations, situated northernmost, noted a miss.

The graze expedition

The expedition to the recent spectacular graze has been organized by the members of the Section of Observations of Position and Occultations of the Polish Association of Amateur Astronomers (PTMA). Wojciech Burzy ski, the team leader, representing the Białystok Division of PTMA, has chosen the observation region along a road between the villages Szczebra and Nowinka, north of the town Augustów (Fig.2). Finally, the observers were located at nine stations (Table 1). One observer more independently went to another site situated at a distance of about 120 km from the main observation region. From the planned stations we had optimal view direction to the Moon, free of higher buildings and trees. Unfortunately, a couple of southernmost stations have to be cancelled since their location would have been placed in a forest and without energy supply.

Observations

During the day, there were some precipitations with clouded out sky, however the weather forecast for the evening was very promising. In fact, last clouds disappeared half an hour before the graze, revealing an unusual clear sky. Aldebaran then could be found easily, gradually approaching the southern lunar limb.

At the main station situated near the local school in Nowinka, a live broadcast on the internet has been arranged by Karol Wójcicki. The phenomenon was preceded by a quite intense campaign in the Polish media. About this rare phenomenon in our sky that day, an extensive article in the largest mainstream daily newspaper "Gazeta Wyborcza" appeared. The information also appeared on numerous web portals associated with the biggest Polish media (including TVN24 channel, Radio Zet, Gazeta Wyborcza).

Fanpage on Facebook "With his head in the stars," led by Karol Wójcicki conducted a live broadcast of this occultation. It is worth noting that between 19:00 and 20:00 CEST the transmission was the most important news on the portal of the biggest national news channel TVN24 and the daily newspaper "Gazeta Wyborcza".

The live broadcast was watched by a total of over 17 thousand people.

Results

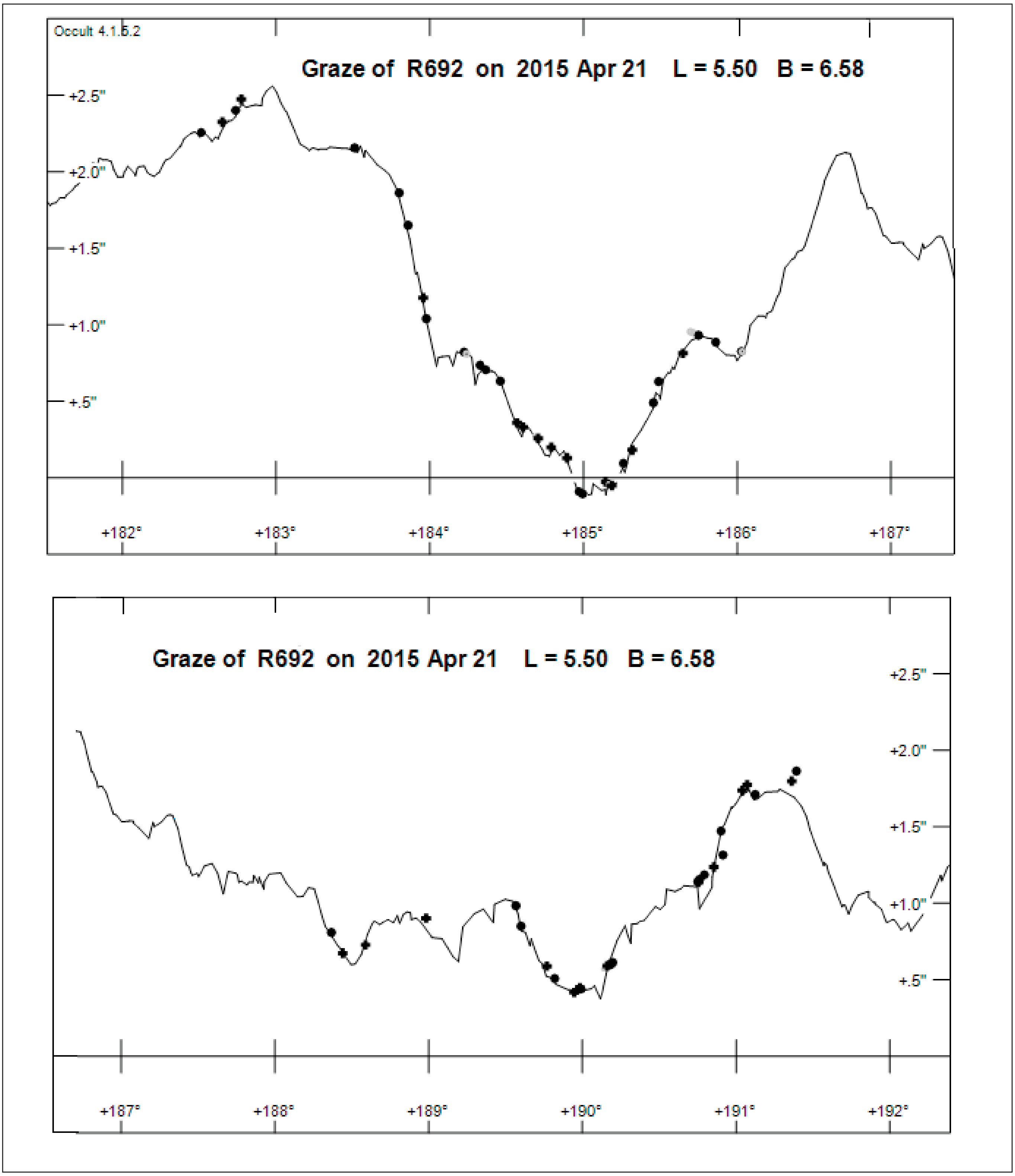
Especially, the observers using CCD cameras with time inserters obtained very valuable results. Unfortunately, some of cameras not equipped with a control option turned out to be too sensitive and observers lost their results unless they decided to record the contacts using standard methods, e.g. "eye and voice" instead. The gradual D and R events could be easily noticed at some stations when single video frames have been analysed later on. Some of such events were remarkable directly on the screen during the recording, too.

The reduction of the results have been made using the Occult software version 4.1.5.2.

In general, the results of observation show a very good agreement of the Kaguya ephemeris profile and the data resulted from older observations of different grazes. Small differences may be noticed only (Fig.1). Better agreement is typical for the most precise technique used whereas the greatest errors can be attributed to standard visual timing methods. However, even those data are consistent inside the whole set of results.

Acknowledgments

The observers of the Aldebaran graze would like to thank the Team of the Schools in Nowinka for their help in the organization of the observation.


Occult 4.1.5.2
Graze of R692 on 2015 Apr 21 L = 5.50 B = 6.58
+2.5"
+2.0"
+1.5"
+1.0"
+.5"
+182°
+183°
+184°
+185°
+186°
+187°
Graze of R692 on 2015 Apr 21 L = 5.50 B = 6.58
+2.5"
+2.0"
+1.5"
+1.0"
+.5"
+187°
+188°
+189°
+190°
+191°
+192°

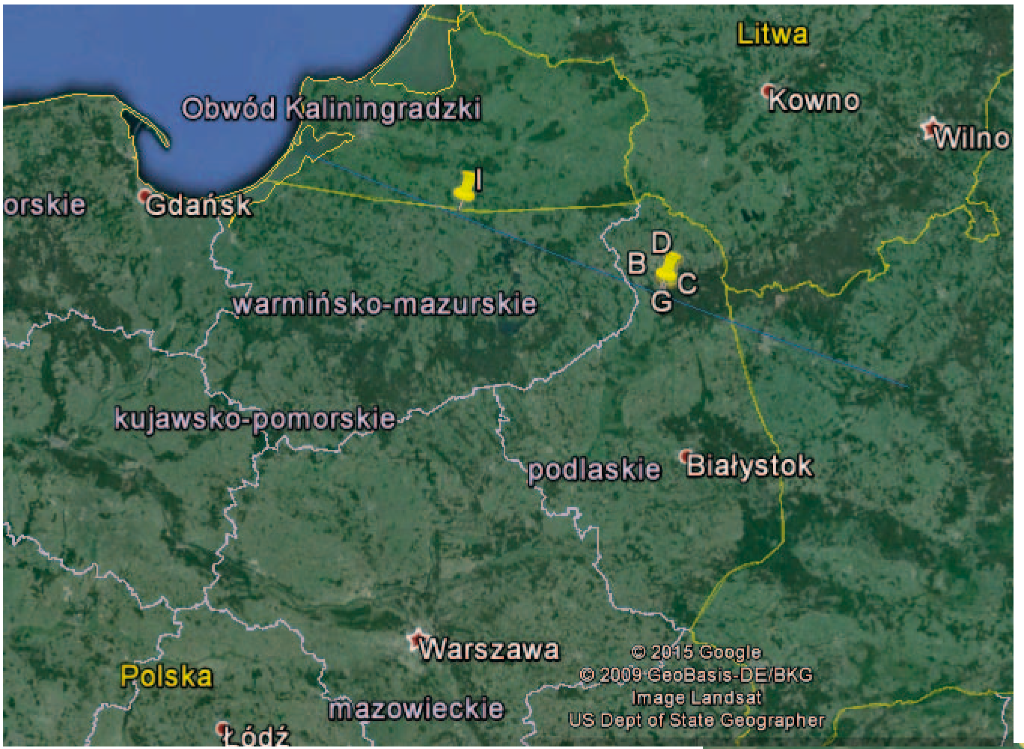


Fig.1. The southern limit of the graze of Aldebaran. B-D and I – location of the stations.

Fig.2. Location of the stations in the vicinity of Nowinka.

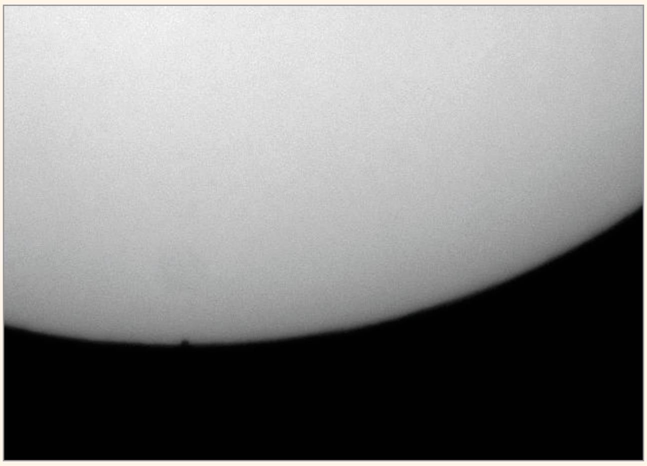
Fig.3. Results of observations – observed contacts versus the ephemeris Kaguya lunar limb

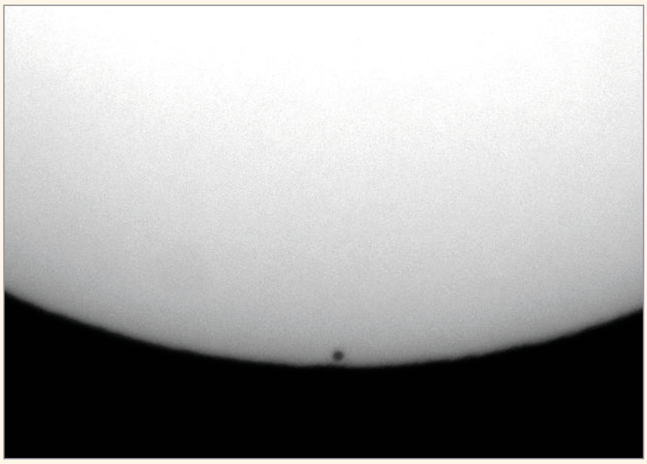
Table 1. Stations, observers, instruments and timings

Station number	Distance [km]	Observer's name	Coordinates [WGS'84], alt. [MSL]	Telescope, mounting and camera type	Timings [UT], PE substracted	Timekeeping	Registration method
1	1.769	Wojciech Burzyński	53° 56′ 08.8″ N 22° 58′ 30.5″ E 127 m	REF 100/660 mm, AZ drive, magn. 25x	17 50 34.5 D 17 51 36.0 R 17 51 37.25 D 17 51 39.7 F 17 51 40.4 R 17 51 43.1 D 17 51 46.4 R 17 51 54.4 D 17 51 55.05 B (partial) 17 51 55.7 D 17 54 27.45 R 17 54 28.15 D 17 54 28.7 R 17 54 33.5 B (partial) 17 54 34.35 D 17 54 53.3 R 17 54 56.45 D 17 55 12.65 R	GPS video time inserter (by T. Wezyk)	Visual /voice recording
2	1.602	Krzysztof Sawicki	53° 56′ 00.8″ N 22° 58′ 39.1″ E 132 m	NEW 150/750 mm, EQ drive, CCD TV: FEM-930		DCF video time inserter (by "Ga-Pa")	Videograbber / HDD
3	1.279	Janusz Wiland	53° 55′ 49.2″ N 22° 58′ 41.1″ E 128 m	REF 50/330 mm + teleconverter 2x, EQ drive, CCD TV: Watec 120N	17 50 37.8 D 17 51 17.6 R 17 51 25.5 D (7 frames) 17 51 26.0 F (short) 17 51 28.8 R (gradual) 17 51 30.0 D 17 51 33.0 R 17 51 58.6 D 17 54 24.0 R 17 54 58.5 D 17 55 05.6 R	DCF video time inserter (by "Ga-Pa")	Videograbber / HDD
4	0.970	Piotr Gibulski	53° 55′ 38.3 ″ N 22° 58′ 41.8″ E 128 m	REF 80/300 mm, AZ manual (binocular, magn. 20x)	17 50 39.25 D 17 51 17.25 R 17 52 00.75 D 17 54 22.65 R 17 55 03.20 D 17 55 04.25 R	DCF radio signals	visual + voice recording
5	0.647	Mieczysław Borkowski	53° 55′ 26.5″ N 22° 58′ 44.3″ E 127 m	NEW 200/1200 mm, EQ drive, CCD TV camera		DCF video time inserter (by "Ga-Pa")	Videograbber / HDD
6	- 0.026	Marek Zawilski	53° 55′ 04.3″ N 22° 58′ 38.5″ E 130 m	SCT 90/1250 mm, AZ drive, CCD TV: Bielski 0,1 lx	17 51 14.81 R (3 frames) 17 52 05.90 D (3 frames) 17 54 18.12 R (3 frames)	GPS video time inserter (by IOTA)	Videograbber / HDD
7	- 0.434	Maciej Jarmoc	53° 54′ 51.4″ N 22° 58′ 33.0″ E 129 m	REF 80/600 mm, EQ drive, CCD TV: Watec 902H	17 51 03.93 D (4 frames) 17 51 13.25 R (4 frames) 17 52 07.25 D (7 frames) 17 54 17.38 R (3 frames)	DCF video time inserter (by "Ga-Pa")	Videograbber / HDD
8	- 1.112	Franciszek Chodorowski	53° 54′ 30.4″ N 22° 58′ 21.8″ E 128 m	NEW 200/800 mm, EQ drive	17 52 12.75 D 17 53 41.90 R 17 53 46.65 D 17 53 59.20 R	DCF radio signals	Visual + voice recording + stopwatch

9	- 1.535	Piotr Badowski	53° 54′ 10.7″ N 22° 58′ 41.7″ E 137 m	SCT 100/1000 mm, EQ drive, CCD TV: Mintron MTV-12V1C	17 52 14.87 B (1 frame) 17 52 15.47 B (1 frame) 17 52 16.59 D (6 frames) 17 52 19.99 F (1 frame) 17 52 20.07 B (2 frames) 17 52 20.15 R (1 frame) 17 52 25.35 B (partial) 17 52 25.39 F (2 frames) 17 52 25.47 D (3 frames) 17 52 25.63 F (1 frame) 17 53 40.16 R (10 frames)	DCF video time inserter TIM-10 (by A. Meier Electronic)	Videograbber + HDD

MICHALKOWO-observation place 118 km north-west from Nowinka								
10	2.011	Jacek Dr kowski	54° 19′ 23.5″ N 21° 17′ 53.0″ E 54 m	Newton150/1000, EQ manual	17 49 15.5 D 17 50 34.9 R 17 50 35.7 D 17 53 16.3 R 17 53 22.3 D 17 53 22.6 R 17 53 22.9 D 17 53 40.7 R 17 53 41.1 D 17 53 42.1 R 17 53 46.0 D 17 54 01.4 R	The DSLR's internal clock set with 1 sec. accuracy (based on DCF radio signals)	Canon 60 D SLR - HD movie	accuracy less than 0,5 sec.





Mercury Transit

A transit of Mercury in front of the sun can be seen with a small telescope using solar filters – and it is nice and easily visible. The most interested moments for the observer are ingress and egress, for the passage via the sun is not exiting.

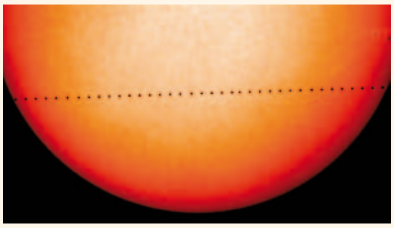
Is there anything of scientific value that can be done?

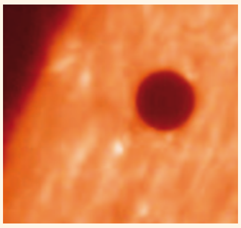
In the past one tried to determine the diameter of the sun, but nowadays these values don't achieve the accuracy that is needed.

Solar physics astronomers once used the black shape of Mercury to refine the darkness of sunspots.

Now it is a Job for students:

They could measure the solar diameter and determine the accuracy of their values or estimating the astronomical unit like it has been done with Venus-transits (Captain J. Cook, 1769) in the past regarding the actual accuracy too.





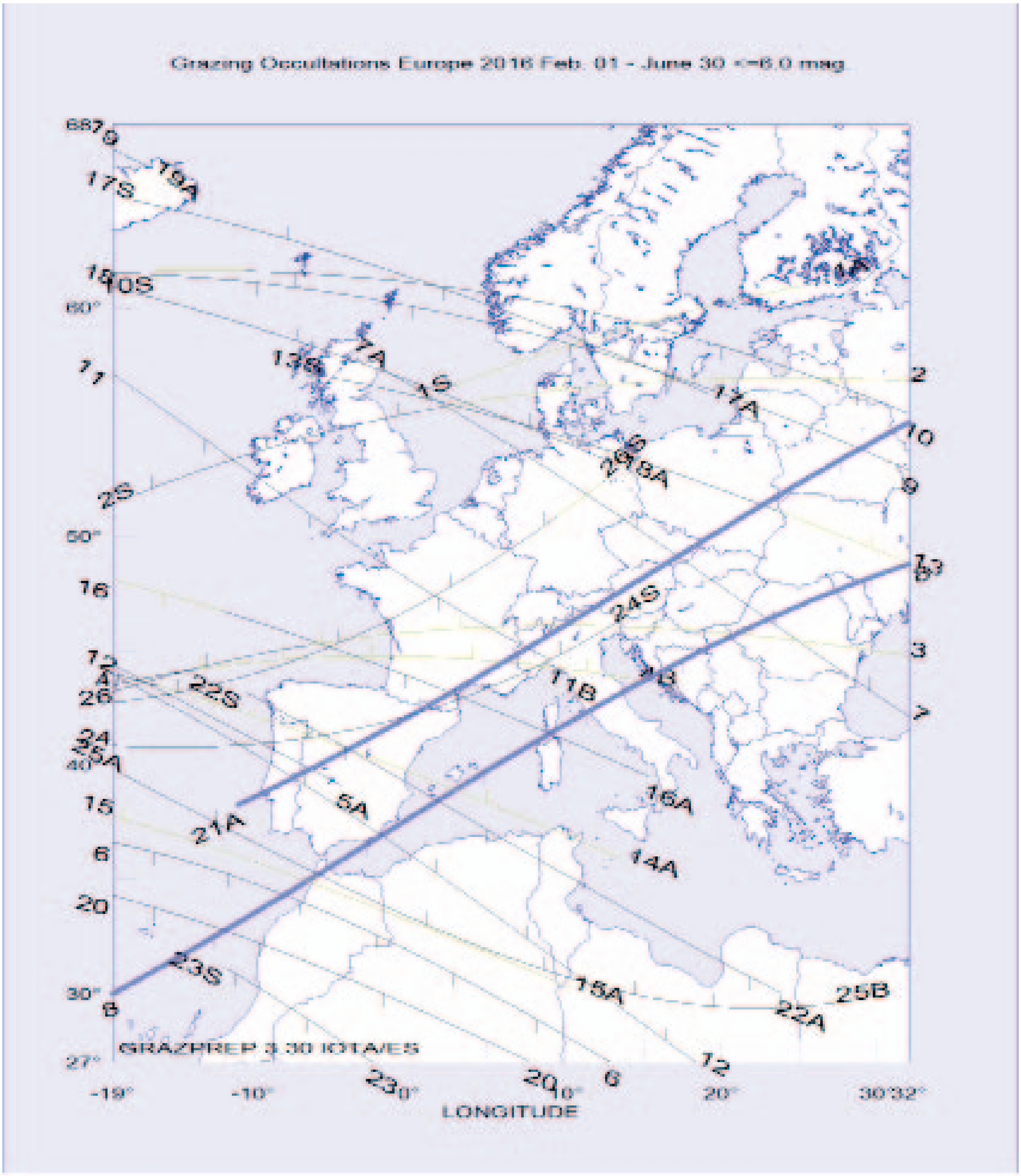
The following maps and tables show a selection of this year's grazing occultations of the brightest stars by the moon. For the European overview the limiting magnitude is 6.0, whereas for the different countries the limit is 7.0 mag. Some unfavorable events were omitted due to low altitude or bright lunar limb conditions.

Some of the bright star events result from this year's lunar passages through the Hyades star cluster in Taurus. Also 6 grazes of Aldebaran occur, four of them very challengingly during daytime. Northern Scotland and the northwesterly part of Germany are the only regions where a dark limb graze of Aldabaran will be visible on the morning of Dec. 13. While Scotland profits from an altitude around 13 degrees in Germany Aldebaran will be less than only 5 degrees above the horizon. The observation of the daytime grazes of Aldebaran needs telescopes of probably 10 inches aperture upwards and very good atmospheric conditions.

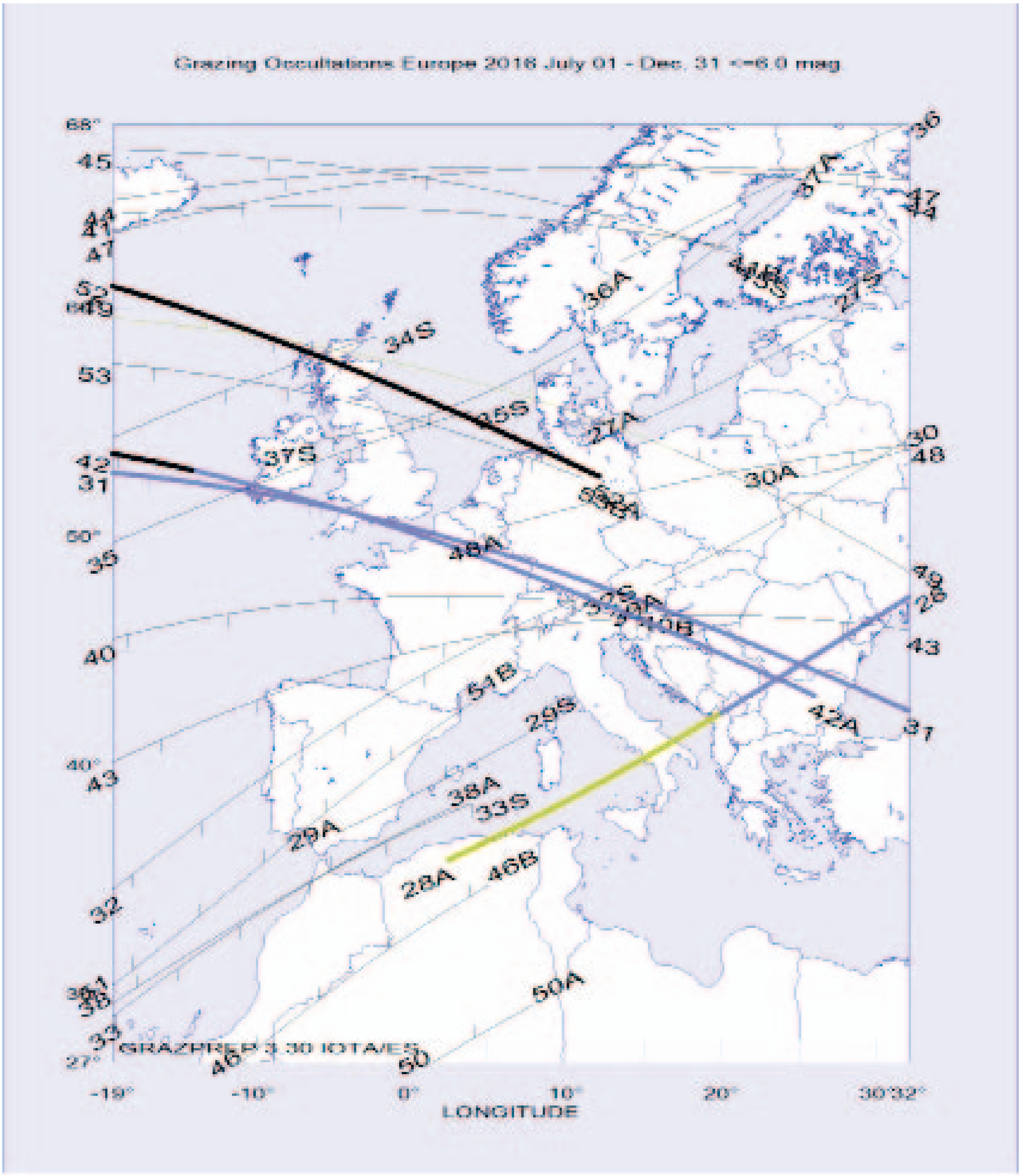
All tables and pictures of this article were created with the author's GRAZPREP-software. Further precise information on the local circumstances of all grazing occultations is provided by this software which can be downloaded and installed via www.grazprep.com (password: IOTA/ES). The prediction files that are needed additionally can be obtained from IOTA/ES or directly from the author. GRAZPREP assists in finding and listing individually favorable occultation events and in figuring out the best observing site in advance or even under way by graphically showing the expected apparent stellar path through the lunar limb terrain.

2016 Grazing Occultations Europe 2016 Feb. 01 - Dec. 31 <=6.0 mag. GRAZPREP 3.30, IOTA/ES

No.	M D	USNO	SAOPPM D	MAG	%SNL	L.	W.UT	LONG	LAT	STAR NAME	MAG1	MAG2
1	**Feb 10**	ZC 3430	146639 A	5.6	6+	S	16 47.9	2	57	96 Aqr	5.7	10.6
2	**Feb 13**	ZC 322	110390 K	5.6	32+	S	18 28.6	-17	52	64 Cet	6.5	6.5
3	**Feb 13**	ZC 327	110408 K	4.4	32+	S	19 30.5	-19	43	65 xi1 Cet	5.3	5.3
4	**Feb 15**	ZC 608	93775 $	6.0	55+	S	20 9.4	-19	43	179 B. Tau	6.1	8.8
5	**Feb 18**	ZC 944	95419 M	5.9	78+	N	3 11.1	-19	44	124 H1. Ori	6.7	6.7
6	**Feb 18**	ZC 1072	96407 X	6.0	85+	N	22 54.5	-19	37	110 B. NP Gem	7.0	7.0
7	**Mar 01**	ZC 2291	159625 V	5.5	58 -	S	2 1.5	-1	57	49 Lib	6.3	6.3
8	**Mar 14**	ZC 692	94027 A	0.9	38+	N	12 45.6	-19	30	87 alpha Tau (Aldebaran)	1.1	11.3
9	**Mar 15**	ZC 878	94858 K	5.5	51+	N	20 10.8	-19	62	130 Tau	5.6	9.0
10	**Mar 16**	ZC 1029	96015 V	5.2	62+	N	19 20.7	-16	62	26 Gem	5.9	5.9
11	**Mar 20**	ZC 1409	98627 V	5.0	89+	N	2 1.0	-19	57	5 xi Leo	5.3	7.2
12	**Mar 28**	ZC 2247	159466	5.4	82 -	S	0 32.3	-19	44	44 eta Lib		
13	**Apr 10**	ZC 661	93932 V	4.5	15+	S	19 20.2	-5	57	71 V777 Tau	4.8	6.8
14	**Apr 10**	ZC 671	93957 V	3.4	15+	S	20 34.1	-19	44	78 theta2 Tau	4.0	5.0
15	**Apr 10**	ZC 669	93955 V	3.8	15+	S	20 39.4	-19	38	77 theta1 Tau	4.0	7.8
16	**Apr 10**	ZC 667	93950 V	5.0	15+	N	20 27.3	-19	48	75 Tau	5.4	7.9
17	**Apr 10**	ZC 675	93970 Q	5.6	16+	S	20 44.4	-17	65	80 Tau	6.5	6.5
18	**Apr 10**	ZC 678	93978	5.5	16+	S	21 3.2	-19	61	81 Tau		
19	**Apr 11**	ZC 702	94051 J	5.1	17+	S	0 17.9	-19	67	91 sigma1 Tau	5.4	7.4
20	**Apr 11**	ZC 814	94554 T	5.4	25+	N	19 55.9	-19	34	115 Tau	5.7	6.6
21	**May 08**	ZC 692	94027 A	0.9	4+	N	7 31.8	-11	38	87 alpha Tau (Aldebaran)	1.1	11.3
22	**May 10**	ZC 1072	96407 X	6.0	21+	N	20 1.9	-10	43	110 B. NP Gem	7.0	7.0
23	**May 11**	ZC 1198	97429 K	6.0	30+	N	19 39.2	-11	31	2 B. Cnc	7.0	7.0
24	**May 30**	ZC 3412	146585	4.2	42 -	S	2 53.5	-19	41	90 phi Aqr		
25	**Jun 21**	ZC 2814	162413 V	4.9	97 -	S	21 58.3	-18	40	43 d Sgr	5.8	5.8
26	**Jun 27**	ZC 3514	146954 C	5.9	57 -	S	1 57.6	-19	43	24 Psc	6.9	6.9
27	**Jul 01**	ZC 508	93469 V	4.1	15 -	S	0 59.3	14	55	5 f Tau	4.5	6.5
28	**Jul 02**	ZC 692	94027 A	0.9	7 -	N	3 5.8	2	36	87 alpha Tau (Aldebaran)	1.1	11.3
29	**Jul 02**	ZC 699	94043	5.8	7 -	S	3 48.2	-4	37	89 Tau		
30	**Jul 25**	ZC 192	109793	5.1	61 -	S	21 29.2	25	53	89 f Psc		
31	**Jul 29**	ZC 692	94027 A	0.9	23 -	N	11 57.6	-19	53	87 alpha Tau (Aldebaran)	1.1	11.3
32	**Aug 23**	ZC 322	110390 K	5.6	72 -	N	3 17.1	-19	35	64 Cet	6.5	6.5
33	**Aug 23**	ZC 327	110408 K	4.4	72 -	N	4 19.7	-19	29	65 xi1 Cet	5.3	5.3
34	**Aug 28**	ZC 1072	96407 X	6.0	18 -	N	4 35.1	-19	54	110 B. NP Gem	7.0	7.0
35	**Aug 29**	ZC 1198	97429 K	6.0	10 -	N	4 23.6	-19	50	2 B. Cnc	7.0	7.0
36	**Sep 24**	ZC 1141	96985	5.5	33 -	N	22 45.3	13	62	162 B. Gem		
37	**Oct 09**	ZC 2865	162816	5.7	56+	N	17 48.3	-6	54	267 B. Sgr		
38	**Oct 10**	ZC 3019	163783	5.8	67+	S	23 38.3	-19	30	61 B. Cap		
39	**Oct 18**	ZC 608	93775 $	6.0	89 -	N	18 36.2	15	48	179 B. Tau	6.1	8.8
40	**Oct 19**	ZC 667	93950 V	5.0	87 -	N	3 48.6	-19	46	75 Tau	5.4	7.9
41	**Oct 19**	ZC 677	93975 X	4.8	87 -	N	4 48.7	-19	64	264 B. Tau	5.6	5.6
42	**Oct 19**	ZC 692	94027 A	0.9	87 -	N	7 29.7	-19	54	87 alpha Tau (Aldebaran)	1.1	11.3
43	**Oct 20**	ZC 814	94554 T	5.4	78 -	N	2 5.0	-19	40	115 Tau	5.7	6.6
44	**Oct 25**	ZC 1486	98964 A	4.4	26 -	N	3 17.4	-19	65	31 A Leo	4.6	13.6
45	**Oct 26**	ZC 1600	118615	5.0	17 -	N	5 36.8	-19	67	59 c Leo		
46	**Nov 10**	ZC 3514	146954 C	5.9	81+	S	21 47.9	-10	27	24 Psc	6.9	6.9
47	**Nov 16**	ZC 741	94227 V	5.5	97 -	N	1 12.5	-19	63	318 B. Tau	6.5	6.5
48	**Nov 20**	ZC 1439	98755	5.7	53 -	N	22 54.6	5	50	18 Leo		
49	**Nov 24**	ZC 1772	138721 Q	3.9	23 -	S	4 18.5	-19	60	15 eta Vir (Zaniah)	4.6	5.9
50	**Dec 02**	ZC 2791	162229 V	5.6	9+	S	18 38.9	1	27	190 B. V4024 Sgr	6.2	6.2
51	**Dec 09**	ZC 192	109793	5.1	76+	S	18 57.2	-19	30	89 f Psc		
52	**Dec 13**	ZC 692	94027 A	0.9	99+	N	5 25.4	-19	61	87 alpha Tau (Aldebaran)	1.1	11.3
53	**Dec 16**	ZC 1158	97120 K	5.0	94 -	N	2 47.0	-19	58	74 m Gem	6.0	6.0

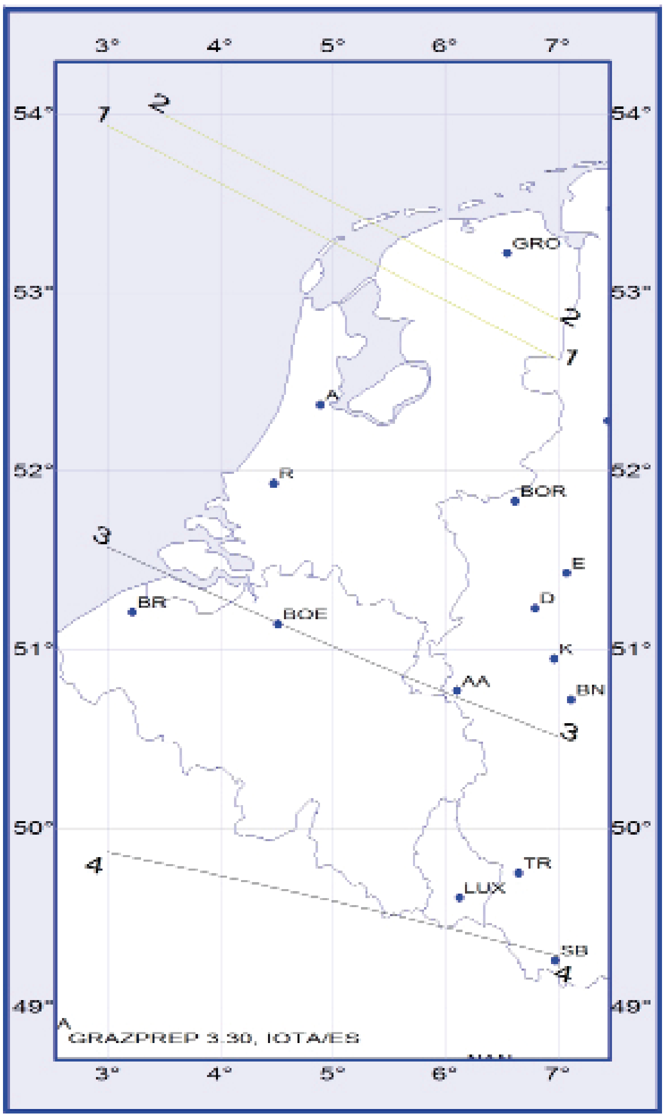


The main idea of the program is to easily visualize the complete list of all grazing occultation events in an area plus the complete line data for any selected event and (simultaneously on the same screen) both the geographic circumstances on earth and the enlarged topographic situation at the lunar limb including a fairly realistic display of the sunlit lunar portion as well as the approximate sky brightness due to the sun's altitude. Thus a judgment about the entire graze circumstances is easily possible at a few glances and a selection of the best events quick and easy. Any graze line for any selected favorable offset to the predicted



limit can be displayed in Google Earth. Besides that the software assists in creating one or several individual observing stations with any center and radius, that way filtering out the most suitable local events according to a variety of personal preferences.

2016			BeNeLux 2016 -7.0 mag.							GRAZPREP 3.30, IOTA/ES	
No.	M D	USNO	SAOPPM D	MAG	%SNL	L.	W.UT	CUSP-A T	STAR NAME	MAG1	MAG2
1	**Apr 11**	ZC 834	94630 N	6.1	25+	S	22 8.2	0.8 B C	167 H1. TAURI	6.0	6.5
2	**Apr 11**	X 7078	94631 K	6.5	25+	S	22 8.2	0.8 B C		7.3	7.3
3	**Apr 28**	ZC 2758	162021	7.0	70 -	S	2 4.6	6.7 D C			
4	**Oct 24**	ZC 1386	98520	6.7	35 -	N	5 24.5	1.1 D A			



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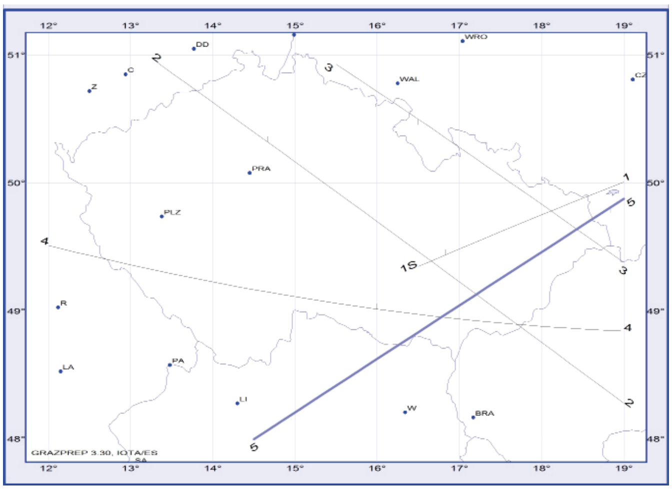


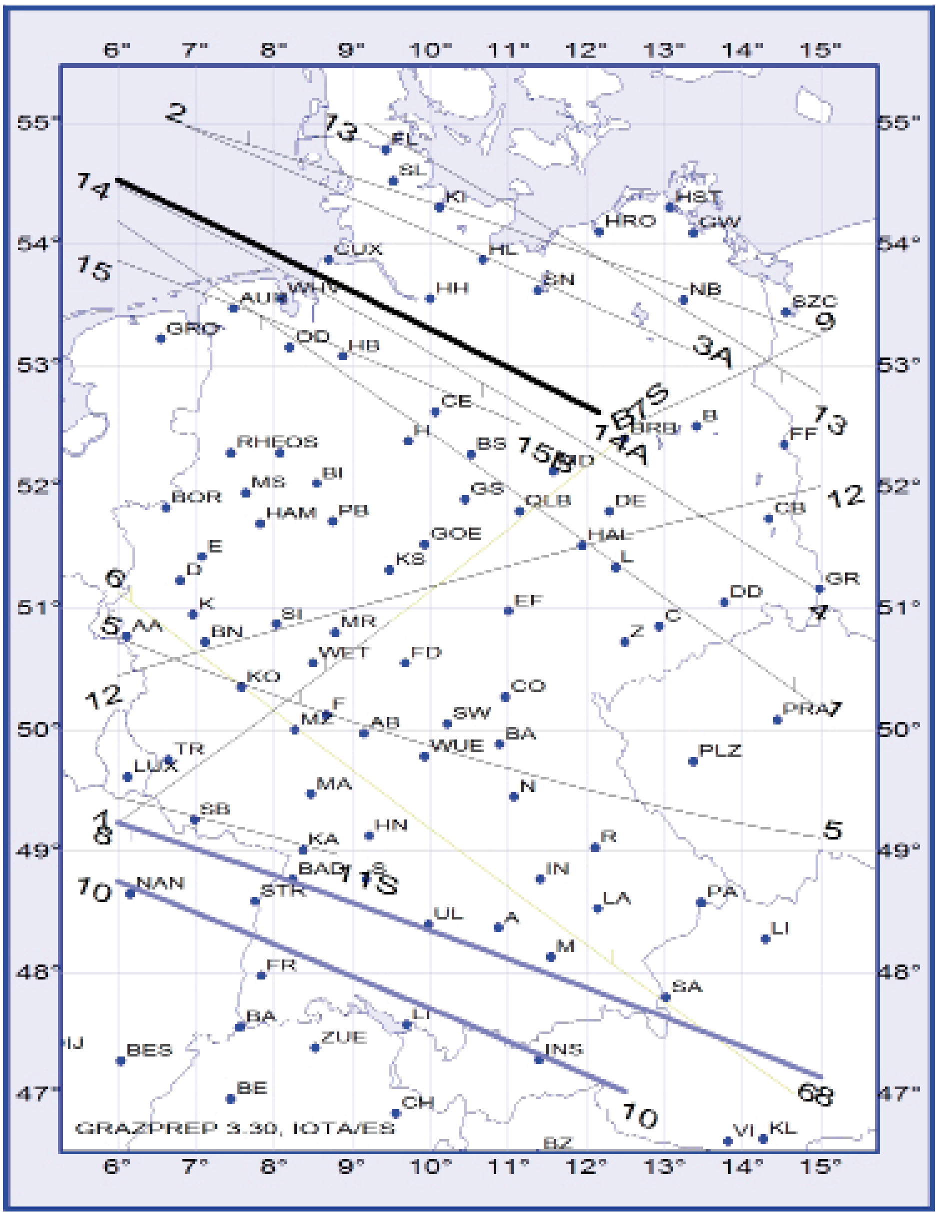
CZ

2016			Czech Republic 2016 -7.0 mag.							GRAZPREP 3.30, IOTA/ES	
No.	M D	USNO	SAOPPM D	MAG	%SNL	L.	W.UT	CUSP-A T	STAR NAME	MAG1	MAG2
1	**Feb 13**	ZC 308	110337	6.3	32+	S	16 19.6	2.9 D B	WZ Psc	6.3	6.4
2	**Mar 01**	ZC 2291	159625 V	5.5	58 -	S	2 9.0	5.6 D A	49 Lib	6.3	6.3
3	**Apr 17**	ZC 1567	118483	6.4	84+	N	20 18.2	3.5 D B	37 (Sex)/Leo		
4	**Apr 28**	ZC 2758	162021	7.0	70 -	S	2 14.5	5.4 D C			
5	**May 08**	ZC 692	94027 A	0.9	4+	N	7 45.7	18.7 B A	87 alpha Tau (Aldebaran)	1.1	11.3

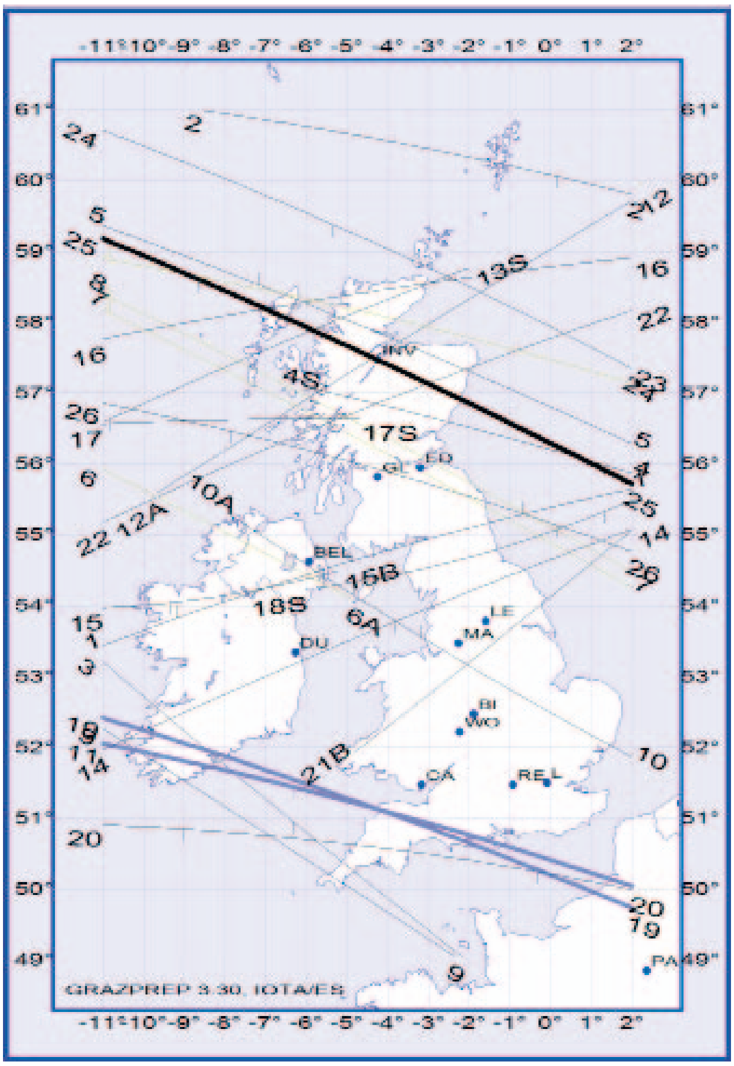
2016 Germany 2016 - 7.0 mag. GRAZPREP 3.30, IOTA/ES

No.	M D	USNO	SAOPPM D	MAG	%SNL	L.	W.UT	CUSP-A T	STAR NAME	MAG1	MAG2
1	**Mar 01**	ZC 2291	159625 V	5.5	58 -	S	2 4.2	5.1 D A	49 Lib	6.3	6.3
2	**Apr 10**	ZC 661	93932 V	4.5	15+	S	19 29.5	0.9 T A	71 V777 Tau	4.8	6.8
3	**Apr 10**	ZC 678	93978	5.5	16+	S	21 15.5	0.3 T A	81 Tau		
4	**Apr 17**	ZC 1567	118483	6.4	84+	N	20 3.1	2.2 D B	37 (Sex)/Leo		
5	**Apr 28**	ZC 2758	162021	7.0	70 -	S	2 7.5	6.3 D C			
6	**May 13**	X 14721	98747	6.9	51+	S	21 20.4	1.3 B C			
7	**Jun 27**	ZC 3514	146954 C	5.9	57 -	S	2 25.6	0.3 T A	24 Psc	6.9	6.9
8	**Jul 29**	ZC 692	94027 A	0.9	23 -	N	12 20.0	8.0 B A	87 alpha Tau (Aldebaran)	1.1	11.3
9	**Oct 07**	ZC 2571	160868	6.8	36+	S	17 46.5	0.0 T B	6 G. Sgr		
10	**Oct 19**	ZC 692	94027 A	0.9	87 -	N	7 46.9	1.4 D A	87 alpha Tau (Aldebaran)	1.1	11.3
11	**Oct 24**	ZC 1386	98520	6.7	35 -	N	5 28.6	0.6 T A			
12	**Nov 20**	ZC 1439	98755	5.7	53 -	N	22 54.7	8.7 D C	18 Leo		
13	**Nov 26**	ZC 1994	139618 O	6.6	9 -	N	6 26.1	1.6 D A	598 B. Vir	6.5	7.7
14	**Dec 13**	ZC 692	94027 A	0.9	99+	N	5 34.2	29.9 D A	87 alpha Tau (Aldebaran)	1.1	11.3
15	**Dec 16**	ZC 1158	97120 K	5.0	94 -	N	3 17.7	6.6 D A	74 m Gem	6.0	6.0

Germany



Great Britain

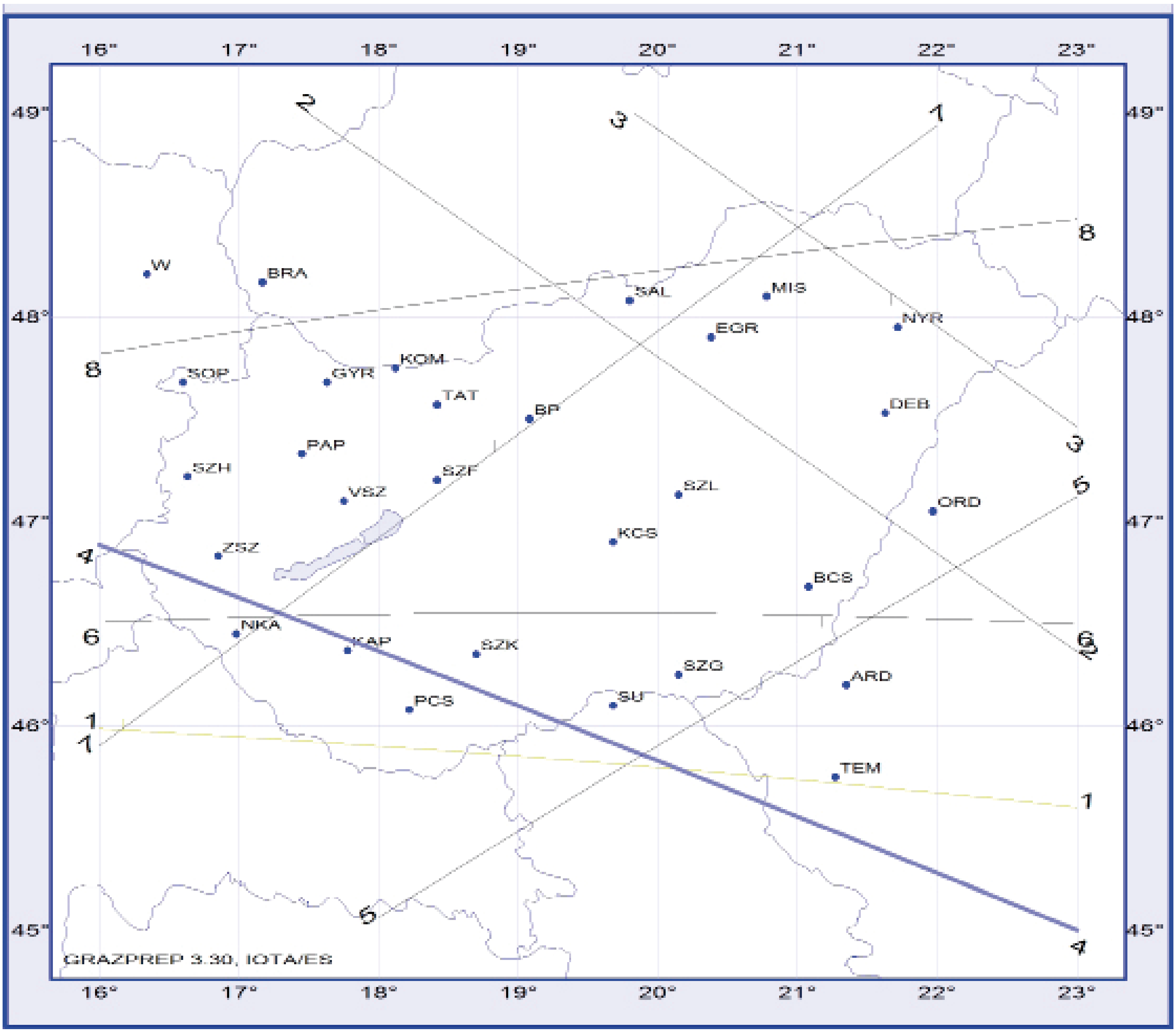


2016 Great Britain 2016 - 7.0 mag. GRAZPREP 3.30, IOTA/ES

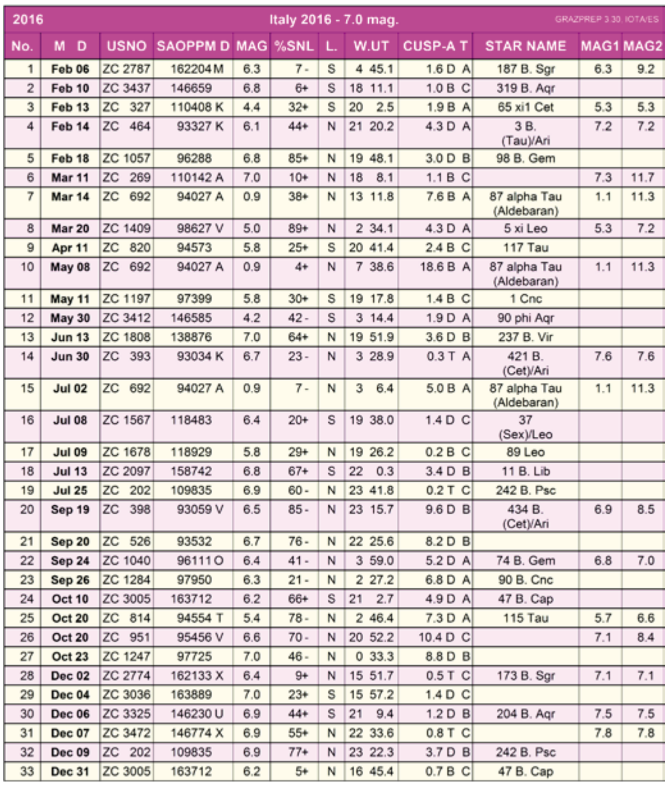
No.	M D	USNO	SAOPPM D	MAG	%SNL	L.	W.UT	CUSP-A T	STAR NAME	MAG1	MAG2
1	**Feb 13**	ZC 322	110390 K	5.6	32+	S	18 37.8	1.8 D A	64 Cet	6.5	6.5
2	**Mar 15**	ZC 878	94858 K	5.5	51+	N	20 21.4	1.1 D A	130 Tau	5.6	9.0
3	**Mar 20**	ZC 1409	98627 V	5.0	89+	N	2 13.4	5.2 D A	5 xi Leo	5.3	7.2
4	**Apr 10**	ZC 661	93932 V	4.5	15+	S	19 20.2	1.9 D B	71 V777 Tau	4.8	6.8
5	**Apr 10**	ZC 678	93978	5.5	16+	S	21 8.0	1.1 D A	81 Tau		
6	**Apr 10**	ZC 685	94004	6.6	16+	N	22 29.2	0.2 B C	275 B. Tau		
7	**Apr 11**	ZC 834	94630 N	6.1	25+	S	22 0.2	0.3 B C	167 H1. TAURI	6.0	6.5
8	**Apr 11**	X 7078	94631 K	6.5	25+	S	22 0.1	0.3 B C		7.3	7.3
9	**Apr 12**	ZC 1002	95794 S	6.9	36+	N	22 53.1	2.0 D A	20 Gem		
10	**Apr 28**	ZC 2758	162021	7.0	70 -	S	1 57.9	7.4 D C			
11	**Jul 29**	ZC 692	94027 A	0.9	23 -	N	12 5.7	6.3 B A	87 alpha Tau (Aldebaran)	1.1	11.3
12	**Aug 28**	ZC 1057	96288	6.8	18 -	N	2 3.0	2.7 D C	98 B. Gem		
13	**Aug 28**	ZC 1072	96407 X	6.0	18 -	N	4 40.7	2.7 D A	110 B. NP Gem	7.0	7.0
14	**Aug 29**	ZC 1198	97429 K	6.0	10 -	N	4 26.5	2.7 D A	2 B. Cnc	7.0	7.0
15	**Sep 11**	ZC 2787	162204 M	6.3	72+	N	19 47.4	1.0 T B	187 B. Sgr	6.3	9.2
16	**Sep 28**	ZC 1516	118260	6.6	7 -	N	4 35.1	5.1 D A	149 B. Leo		
17	**Sep 28**	ZC 1525	118286	5.6	7 -	N	6 5.1	3.6 D A	44 DE Leo	5.6	5.7
18	**Oct 09**	ZC 2865	162816	5.7	56+	N	17 48.3	2.6 D C	267 B. Sgr		
19	**Oct 19**	ZC 692	94027 A	0.9	87 -	N	7 36.2	2.7 D A	87 alpha Tau (Aldebaran)	1.1	11.3
20	**Oct 24**	ZC 1386	98520	6.7	35 -	N	5 8.0	3.4 D A			
21	**Nov 05**	ZC 2825	162511 C	6.2	29+	S	18 11.9	0.0 B A	226 B. Sgr	6.4	10.8
22	**Nov 09**	ZC 3379	146447	6.2	72+	N	23 46.5	0.7 T B	81 Aqr		
23	**Nov 24**	ZC 1772	138721 Q	3.9	23 -	S	4 20.6	3.5 B A	15 eta Vir (Zaniah)	4.6	5.9
24	**Nov 26**	ZC 1994	139618 O	6.6	9 -	N	6 19.0	3.8 D A	598 B. Vir	6.5	7.7
25	**Dec 13**	ZC 692	94027 A	0.9	99+	N	5 29.1	29.2 D A	87 alpha Tau (Aldebaran)	1.1	11.3
26	**Dec 16**	ZC 1158	97120 K	5.0	94 -	N	2 56.2	8.7 D A	74 m Gem	6.0	6.0

2016 Hungary 2016 - 7.0 mag. GRAZPREP 3.30, IOTA/ES

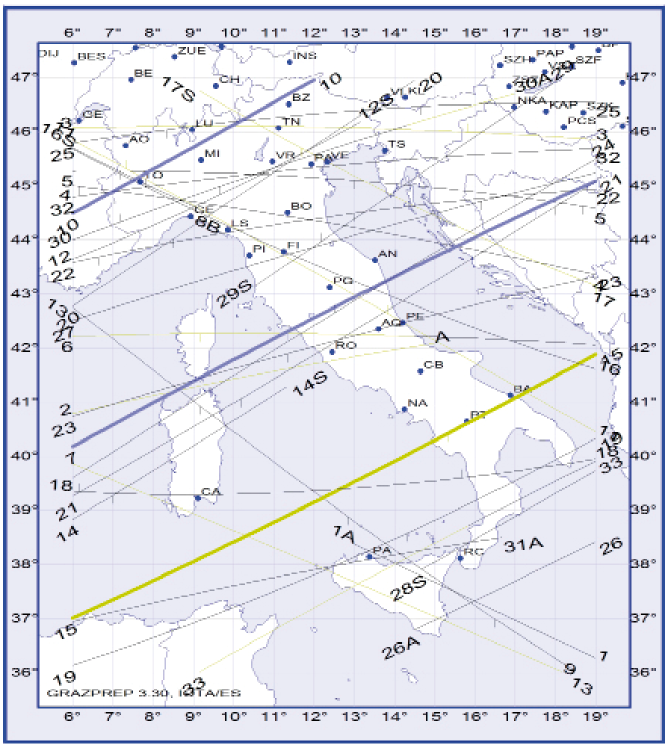
No.	M D	USNO	SAOPPM D	MAG	%SNL	L.	W.UT	CUSP-A T	STAR NAME	MAG1	MAG2
1	**Feb 13**	ZC 327	110408 K	4.4	32+	S	20 10.1	3.2 B B	65 xi1 Cet	5.3	5.3
2	**Mar 01**	ZC 2291	159625 V	5.5	58 -	S	2 12.9	5.8 D A	49 Lib	6.3	6.3
3	**Apr 17**	ZC 1567	118483	6.4	84+	N	20 26.4	4.1 D B	37 (Sex)/Leo		
4	**Jul 29**	ZC 692	94027 A	0.9	23 -	N	12 26.1	8.7 B A	87 alpha Tau (Aldebaran)	1.1	11.3
5	**Oct 10**	ZC 3005	163712	6.2	66+	S	21 14.5	4.0 D B	47 B. Cap		
6	**Oct 20**	ZC 814	94554 T	5.4	78 -	N	3 2.3	5.4 D A	115 Tau	5.7	6.6
7	**Dec 04**	ZC 3036	163889	7.0	23+	S	16 6.2	1.6 D A			
8	**Dec 08**	ZC 55	128760 M	6.4	66+	N	22 35.2	2.9 D B	10 Cet	6.5	8.9



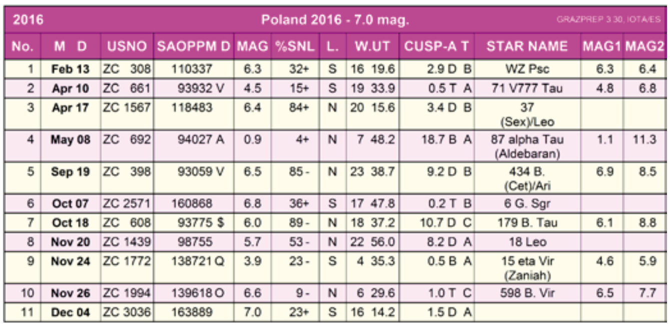
Hungary



2016			Italy 2016 - 7.0 mag.							GRAZPREP 3.30, IOTA/ES	
No.	M D	USNO	SAOPPM D	MAG	%SNL	L.	W.UT	CUSP-A T	STAR NAME	MAG1	MAG2
1	Feb 06	ZC 2787	162204 M	6.3	7 -	S	4 45.1	1.6 D A	187 B. Sgr	6.3	9.2
2	Feb 10	ZC 3437	146659	6.8	6+	S	18 11.1	1.0 B C	319 B. Aqr		
3	Feb 13	ZC 327	110408 K	4.4	32+	S	20 2.5	1.9 B A	65 xi1 Cet	5.3	5.3
4	Feb 14	ZC 464	93327 K	6.1	44+	N	21 20.2	4.3 D A	3 B. (Tau)/Ari	7.2	7.2
5	Feb 18	ZC 1057	96288	6.8	85+	N	19 48.1	3.0 D B	98 B. Gem		
6	Mar 11	ZC 269	110142 A	7.0	10+	N	18 8.1	1.1 B C		7.3	11.7
7	Mar 14	ZC 692	94027 A	0.9	38+	N	13 11.8	7.6 B A	87 alpha Tau (Aldebaran)	1.1	11.3
8	Mar 20	ZC 1409	98627 V	5.0	89+	N	2 34.1	4.3 D A	5 xi Leo	5.3	7.2
9	Apr 11	ZC 820	94573	5.8	25+	S	20 41.4	2.4 B C	117 Tau		
10	May 08	ZC 692	94027 A	0.9	4+	N	7 38.6	18.6 B A	87 alpha Tau (Aldebaran)	1.1	11.3
11	May 11	ZC 1197	97399	5.8	30+	S	19 17.8	1.4 B C	1 Cnc		
12	May 30	ZC 3412	146585	4.2	42 -	S	3 14.4	1.9 D A	90 phi Aqr		
13	Jun 13	ZC 1808	138876	7.0	64+	N	19 51.9	3.6 D B	237 B. Vir		
14	Jun 30	ZC 393	93034 K	6.7	23 -	N	3 28.9	0.3 T A	421 B. (Cet)/Ari	7.6	7.6
15	Jul 02	ZC 692	94027 A	0.9	7 -	N	3 6.4	5.0 B A	87 alpha Tau (Aldebaran)	1.1	11.3
16	Jul 08	ZC 1567	118483	6.4	20+	S	19 38.0	1.4 D C	37 (Sex)/Leo		
17	Jul 09	ZC 1678	118929	5.8	29+	N	19 26.2	0.2 B C	89 Leo		
18	Jul 13	ZC 2097	158742	6.8	67+	S	22 0.3	3.4 D B	11 B. Lib		
19	Jul 25	ZC 202	109835	6.9	60 -	N	23 41.8	0.2 T C	242 B. Psc		
20	Sep 19	ZC 398	93059 V	6.5	85 -	N	23 15.7	9.6 D B	434 B. (Cet)/Ari	6.9	8.5
21	Sep 20	ZC 526	93532	6.7	76 -	N	22 25.6	8.2 D B			
22	Sep 24	ZC 1040	96111 O	6.4	41 -	N	3 59.0	5.2 D A	74 B. Gem	6.8	7.0
23	Sep 26	ZC 1284	97950	6.3	21 -	N	2 27.2	6.8 D A	90 B. Cnc		
24	Oct 10	ZC 3005	163712	6.2	66+	S	21 2.7	4.9 D A	47 B. Cap		
25	Oct 20	ZC 814	94554 T	5.4	78 -	N	2 46.4	7.3 D A	115 Tau	5.7	6.6
26	Oct 20	ZC 951	95456 V	6.6	70 -	N	20 52.2	10.4 D C		7.1	8.4
27	Oct 23	ZC 1247	97725	7.0	46 -	N	0 33.3	8.8 D B			
28	Dec 02	ZC 2774	162133 X	6.4	9+	N	15 51.7	0.5 T C	173 B. Sgr	7.1	7.1
29	Dec 04	ZC 3036	163889	7.0	23+	S	15 57.2	1.4 D C			
30	Dec 06	ZC 3325	146230 U	6.9	44+	S	21 9.4	1.2 D B	204 B. Aqr	7.5	7.5
31	Dec 07	ZC 3472	146774 X	6.9	55+	N	22 33.6	0.8 T C		7.8	7.8
32	Dec 09	ZC 202	109835	6.9	77+	N	23 22.3	3.7 D B	242 B. Psc		
33	Dec 31	ZC 3005	163712	6.2	5+	N	16 45.4	0.7 B C	47 B. Cap		

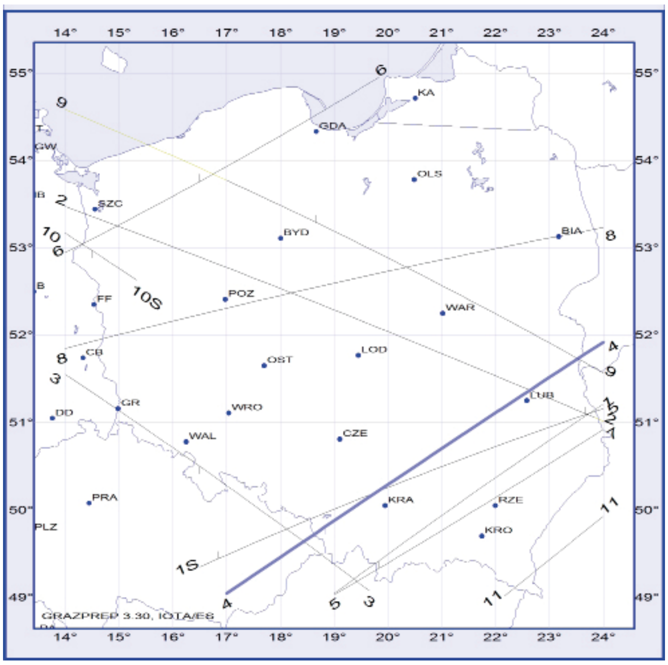


Italy



2016			Poland 2016 - 7.0 mag.							GRAZPREP 3.30, IOTA/ES	
No.	M D	USNO	SAOPPM D	MAG	%SNL	L.	W.UT	CUSP-A T	STAR NAME	MAG1	MAG2
1	Feb 13	ZC 308	110337	6.3	32+	S	16 19.6	2.9 D B	WZ Psc	6.3	6.4
2	Apr 10	ZC 661	93932 V	4.5	15+	S	19 33.9	0.5 T A	71 V777 Tau	4.8	6.8
3	Apr 17	ZC 1567	118483	6.4	84+	N	20 15.6	3.4 D B	37 (Sex)/Leo		
4	May 08	ZC 692	94027 A	0.9	4+	N	7 48.2	18.7 B A	87 alpha Tau (Aldebaran)	1.1	11.3
5	Sep 19	ZC 398	93059 V	6.5	85 -	N	23 38.7	9.2 D B	434 B. (Cet)/Ari	6.9	8.5
6	Oct 07	ZC 2571	160868	6.8	36+	S	17 47.8	0.2 T B	6 G. Sgr		
7	Oct 18	ZC 608	93775 $	6.0	89 -	N	18 37.2	10.7 D C	179 B. Tau	6.1	8.8
8	Nov 20	ZC 1439	98755	5.7	53 -	N	22 56.0	8.2 D A	18 Leo		
9	Nov 24	ZC 1772	138721 Q	3.9	23 -	S	4 35.3	0.5 B A	15 eta Vir (Zaniah)	4.6	5.9
10	Nov 26	ZC 1994	139618 O	6.6	9 -	N	6 29.6	1.0 T C	598 B. Vir	6.5	7.7
11	Dec 04	ZC 3036	163889	7.0	23+	S	16 14.2	1.5 D A			

Poland



Journal for
Occultation Astronomy

Visual timinigs of four 2015 mutual eclipses of Galileian satellites compared with the ephemerides

presented at ASTROMETRY-PHEMU-GAIA
International Workshop Paris 14-18 october15

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Abstract

The nodes of the orbits of the satellites of Jupiter each 6 years are aligned with the axis Sun-Jupiter and mutual eclipses and occultations (PHEMU) occur in series, and their observations help to improve the ephemerides, influenced -on the long period- by many bodies interactions, relativistic corrections and internal mass distributions. The visual observations made in Rome of Ganymedes eclipsed on 20 and 27 Feb and Europa eclipsed on 26 February and 8 May 2015 are compared with the ephemerides. They have 10s accuracy in time, and 0.1 magnitudes in photometry, with a luminosity scale "brighter than", "equal to", "dimmer than" relative to uneclipsed satellites. The paper is structured in 1. Introduction to the mutual phenomena as geometrical consequence of orbital momentum conservations. 2. Visual observations with 3" telescopes and lack of scotopic vision under city lights. 3. The results of 20, 26 and 27 Feb and 8 May eclipses with relative photometry 4. Accuracy on timing and magnitude of the center of the eclipse; comparison with four ephemerides: IMCCE, BAA (computed by Jean Meeus), Belgian Observatory ephemerides, and Occult 4; 5. Conclusions. Significant departures from the ephemerides have been found either in time, 1min, and magnitudes, 0.5mag.

1. Introduction: the mutual eclipses of Jupiter's satellites

When the line of sight Sun-Jupiter includes the nodes of the equatorial plane of Jupiter and of the orbits of its satellites, the mutual phenomena occur: it happens each 6 years and their observations contribute to the definition of orbital parameters (the theory of the grand satellites of Jupiter, the internal distribution of their masses [1]), and to the physical parameters of the satellites, like the albedo and the transient atmosphere (e.g. The ejecta from the volcanoes of Io) when present [2, 3]. The eclipses between satellites are better observable than the superpositions (occultations) between them; the angular resolution of the telescope does not allow a significant accuracy in the determination of the superposition, while an eclipse with Jupiter not in opposition is well visible even with small telescopes as it is shown in the following.

2. Visual observations with small telescopes under city lights

A tabletop telescope of 3" is larger than the first galileian telescope [4] used in the discovery of the Jupiter's satellites. But the conditions of the urban skies are nowadays much worse than in 1610 and the scotopic vision of our eyes cannot often take place. This reduces the limiting magnitude for visual observations at these telescopes at mv=7÷7.5, not only because the sky is bright, but also because the eye uses only the cones as detectors. So a mutual eclipse between the satellites of Jupiter can easily be a temporary disparition of the eclipsed one if observed with a small telescope. The eclipsed satellite can experience a magnitude drop from 0.1 mag to some magnitudes (about 1 in the case of Europa's eclipse of 8 May 2015). For the smaller magnitude drops the method of Argelander can take advantage of the uneclipsed satellites: their visual magnitudes when Jupiter is at mean opposition are I, Io, 4.8; II, Europa, 5.2; III, Ganymedes, 4.5; and IV, Callisto, 5.5 [5]. For larger magnitudes drops the arbitrary scale A>B, A=B and A<B is better than trying to evaluate the drop, due to the rapidity of the phenomenon (usually about 5 minutes) and the difficulty to find opportune reference stars.

3. Observations from Rome

The events and their ephemerides were fournished by IOTA/ES [6] section and BAA [7] through the Planoccult mailing list. The observation of superpositions and eclipses in 2015 has been made with 3 different telescopes: a refractor of 3" at 30x, a Newton of 3" at 20x – 58x and a Schmidt-Cassegrain of 8" at 81x, all without tracking motor. The superpositions have been observed: they do not issue a sharp timing. Only with the larger telescope of 8» the difference in magnitude between the satellites was evident, either because of the larger limiting magnitude, either due to the longer focal lenght which determines a large separation between the satellites and Jupiter.

The eclipses observed have been on 20, 26, 27 february 2015 and 8 may 2015: two of Ganymedes, the brightest, and two of Europa, the third one in order of luminosity.

On 20 February Ganymedes was closer to Jupiter than Io and its brightness changed as in the table, because it was eclipsed by Io:

Observations 20 February 2015		IMCCE ephemerides	BAA ephemerides	Occult 4
00:34:55 UT	G>I	Begin: 00h 34min 55s UT	Begin: 00h 36 min 45 s	Begin: 00h34min55s UT
00:36:35 UT	G=I	End: 00h 43min 25s UT	End: 00h 41 min 43 s	End: 00h43min07s UT
00:38:00 UT	G<I	center of the eclipse	center of the eclipse	center of the eclipse
00:39:00 UT	G<I	00h 38 min 10 s	00h 39 min 14 s	00h 39 min 01 s
00:40:00 UT	G<1	Duration: 8 min 30 s	Total duration: 4 min 58 s	Duration: 8 min 12 s
00:41:54 UT	G=I	Delta mag = 0.835 mag	Duration of the annular phase: 2 m 44 s	Delta mag = 0.6 mag
00:42:30 UT	G>I		Delta mag = 0.62 mag	
00:43:00 UT	G>I			
00:43:25 UT	G>I			

Ganymedes went dimmer than Io for 2 minutes, and the center of the eclipse estimated is around 00:39:05 UT+/-10s, in better agreement with BAA ephemerides and Occult4, as well as the duration of the phase from G<I to G=I was 2 min 54 s.

Observations 26 February 2015	IMCCE ephemerides	BAA ephemerides	Occult 4
22:46:50 UT E starts to dim	Begin: 22h43min54sUT	Not computed because only	Begin: 22h43min59s UT
22:48:19 E is dim	End: 22h52min 47s UT	the penumbra of Callisto	End: 22h52min33s UT
22:49:50 E is dimmest	center of the eclipse	passed over Europa.	maximum of the eclipse
22:51:57 E is recovering	22h 48 min 20 s UT	From Belgian Almanac	22h 48 min 16 s
22:52:21 E as the beginning	Duration: 8 min 53 s	maximum at 22:48	Duration: 8 min 34 s
	Delta mag = 0.947 mag	Delta mag= 0.8 mag	Delta mag = 0.6 mag

On 26 of February the first satellite next to Jupiter was Europa and it was eclipsed by Callisto; observed with the Schmidt-Cassegrain 8”. Ganymedes shined the brightest and external. Callisto appeared equal to Io.

Observations 27 February 2015	IMCCE ephemerides	BAA ephemerides	Occult 4
03:32:58 UT G not the brightest	Begin: 03h 31min 11s UT	Begin: 03h 33 min 06 s	Begin: 03:31:13UT
03:34:00-10 UT G<I	End: 03h 40min 40s UT	End: 03h 38 min 54 s	End: 03:40:22UT
03:34:40 UT G>=C	center of the eclipse	center of the eclipse	Max 03:35:47UT
03:34:56 G almost = Io	00h 35 min 50 s	03h 36 min 00 s	Delta mag = 0.7 mag
03:34:15 G= Io; G > Callisto	Duration: 8 min 29 s	Total duration: 5 min 48 s	
03:35:20-30 G<Io; G= Callisto	Delta mag = 0.968 mag	Duration of the annular phase:	
03:36:20-45 G<Io; G=C		3 m 14 s	
03:37:20 G>C; G<I		Delta mag = 0.69 mag	
03:38:00-48 G=I			
03:39:45-55 G>Io start brighter			
03:40:10 G>Io more bright			

The eclipse at maximum was perceived around 22:49:50 UT, a time after than IMCCE, BAA and Occult4 ephemerides.

On 27 of February Io eclipses Ganymedes: observations with Refractor 3” at 30x.

The eclipse was shallower than 20 February’s one, the center was observed around 03:36:00+/-10s. Europa appeared to be the fainter object, but it was closer to Jupiter. The luminosities of Io and Ganymedes were correctly evaluated brighter than Europa and Callisto with the 3” telescopes.

The magnitude drop predicted by Jean Meeus (BAA ephemerides) and his timing is closer to the observations.

On May 8 Europa was eclipsed by Io and observed from indoor with a Newton 3" f=350 mm at 58x.

Observations 8 May 2015	IMCCE ephemerides	BAA ephemerides	Occult 4
21:21:20 UT E is fainter 21:22:11 E is more faint 21:23:14 E is much more faint 21:23:45 E almost disappeared 21:24:24 E at deepest 21:24:40 E starts to recover 21:25:48 E brightening 21:26:18 E brightness restored	Begin:21h 21min 26s UT End:21h 26min 53s UT center of the eclipse 21h 24 min 10 s Duration: 5 min 27 s Delta mag = 0.57 mag	Begin 21h 22min35s UT End 21h 25 min 39sUT center of the eclipse 21h 24 min 09 s UT Total duration:3min04 s Duration of the annular phase: 0 m 56 s Delta mag = 0.88 mag	Begin 21:21:29UT End 21:26:49UT Max 21:24:09UT Delta mag = 1.0 mag

Europa already appeared as the faintest satellite, but in the maximum eclipse it almost disappeared at 21:24:20 UT +/-10s a timing in agreement with all ephemerides. A larger Delta Mag than the ephemerides is estimated by the observations because Europa disappeared at the center eclipse [8].

4. Accuracy of timing and photometry; comparison with the ephemerides

The timing has been taken using UTC synchronized audio-records [8], the same method used for occultations [9] or solar eclipses. The phrases are timed to the nearest second, but since the records do not contain sharp events the general accuracy is whitin ±15÷20 s. The average between symmetrical events (like the first G=I and the second G=I) help to find the center of the eclipse; with two independent determinations of the center of the eclipse we have estimated the error on its determination of ±10 s.

The photometry of the satellites of Jupiter is within ±0.1 magnitudes, since the difference in luminosity between Ganymedes, Io, Europa and Callisto has been always noticed, even when their order is not known before. The data in the tables have not been converted into magnitudes, because in the case of deep eclipses the complete disappearance of the eclipsed satellite made impossible the estimate. The method of Argelander can be used only with large magnification >50x and large opening >3"for eclipses of Ganymedes, which experience gradual dimmings down to the luminosity of Callisto. For Europa at the minimum of the 8 may eclipse its luminosity was much fainter than the others, making unaccurate the estimate. For the eclipses of the satellite Io the Argelander method could work too, since other two satellites are dimmer than it.

A clear result of these four observations is that for 8 may the flux drop of Europa was >1 mag, and the more accurate ephemerides was Occult 4.

The eclipse of February 27 observed with a Schmidt-Cassegrain 8" telescope was noticed shallower than Feb 20 (though observed with a smaller instrument), so the predicted flux drop of IMCCE ephemerides seems too large and all others ephemerides predict similar flux drops for both eclipses, contrarily to my observations.

Finally the timing of the eclipse of 26 february shows the beginning and the maximum eclipse almost two minutes later than ephemerides. The calculated timing accuracy is consistent to the accuracy in the magnitudes estimate: as an example in the case of 20 February is predicted a magnitude drop of 0.6-0.83 magnitudes in 4 min 15 s; this correponds with an average drop of 0.14-0.2 magnitudes per minute, in 10 seconds from 0.02 to 0.03 magnitudes: this figure is at the limit of visual observations possibilities [12].

Acknowledgments

To Jean Meeus and Alex Pratt for their calculations and precious informations.

5. Discussion and conclusions

Among the mutual events between Galileian satellites, with small telescopes, no tracking and urban city lights, the eclipses give the possibility to determine visually the center of the eclipse within ±10 seconds and to check the predicted amount of Delta Magnitudes within 0.1 mag.

The ephemerides published by IOTA/ES (IMCCE) and BAA have been used as comparison to our observations: in the 8 May eclipse of Europa the Delta Magnitude seem to be larger than IMCCE and BAA, as well as the center of the 20 February eclipse of Ganymede was more in agreement with BAA ephemerides, within the errorbars evaluated. A video of such events (see figure 1 of Alex Pratt) would allow accuracies down to ±0.1 s, but our visual observations can be successfully repeated with simple instruments by young students as introductory experiences with UTC synchronized audio-records [8] of astrometry in the solar system, for the next 2020 PHEMU series.

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[11] Belgian Observatory Almanac and Jean Meeus, private communication

[12] C. Sigismondi, Observational Accuracy of Variable Stars arXiv:1506.03770 (2015)

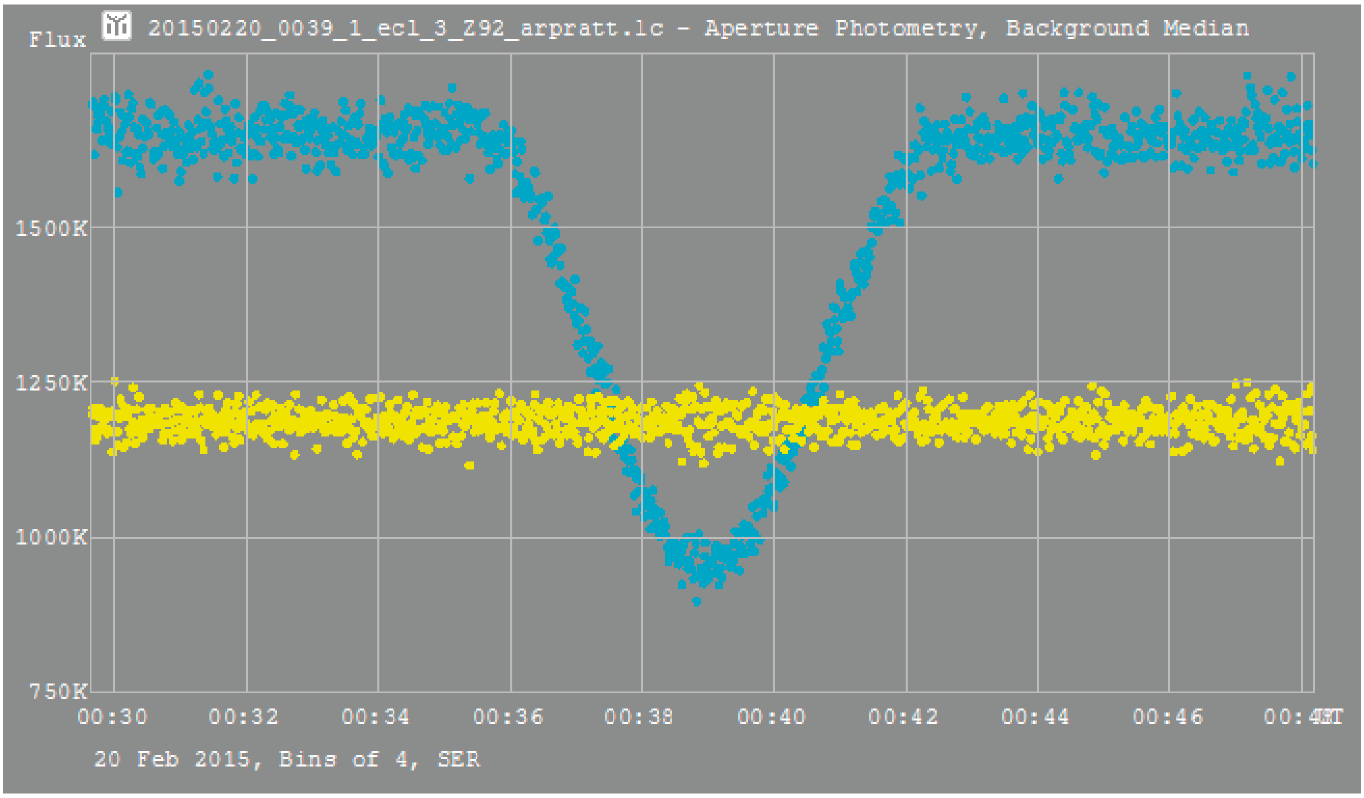

Figure 1 The light curve of the mutual eclipse of Ganymede (blue) eclipsed on 20 February and compared with Io (yellow). Observed by Alex Pratt. The flux ratio G/I corresponds to a gap in magnitudes of 2.5log(1600K/1200K)=0.31 Magnitudes, in perfect agreement with the visual data of D. Dutton [8] here repeated: « The visual magnitudes when Jupiter is at mean opposition are I, Io, 4.8; II, Europa, 5.2; III, Ganymede, 4.5; and IV, Callisto, 5.5. » According to IMCCE calculations [10] the averaged magnitudes of the Galileian satellites in February 2015 (opposition on day 6) were I, Io, 4.35; II, Europa, 4.65; III, Ganymede, 4.25; and IV, Callisto, 4.6.

Journal for
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The Grazing Occultation of 44 Cap during the Total Lunar Eclipse of 1989 August 17

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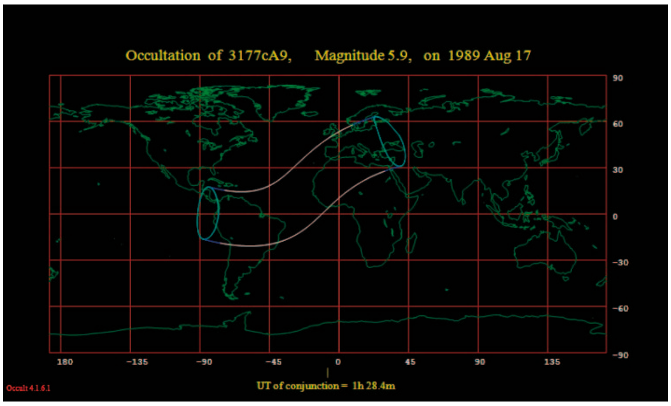
In the early hours of 2015 September 28 Tim Haymes set up a mobile station in southern England to record the grazing occultation of SAO 109080 (HIP 1121 mag 9.2) during the umbral phase of the total lunar eclipse and he timed a sequence of D-R-D-R events. He cautiously claimed that this might be the first observation of its kind in the UK.[1],[2]

His observations are certainly rare, but not the first in the UK. Andrew Elliott, Dr Eberhard Bredner and others observed the graze of 44 Cap (ZC 3177 mag 5.9) during the lunar eclipse of 1989 August 17 from a number of mobile stations near Worcester, England. Another graze team observed from near Usk, Wales.[3]. Andrew used his 25cm f/6.3 SCT, image intensifier and video camera with a manually-configured time inserter that was compared and checked against the red LED display of an MSF receiver. Eberhard used a 10cm f/16 refractor just 11 metres to the east of Andrew.

Their observing sites were at the northern limit of the occultation, with the star grazing the Moon's northern limb (figures 1 and 2). An expedition to Egypt to observe from the southern limit was unsuccessful.



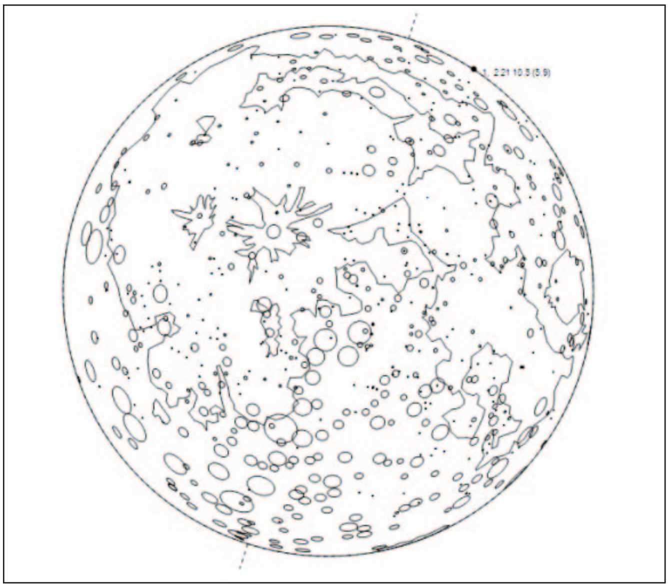


Figure 1: The northern and southern limits of the occultation. Figure 2: Moon map of the northern graze (Occult).

The original observations are available in Occult's Historical Grazes module. The graze plot of the lunar limb profile (figure 3) shows that Andrew's timings of his D-R-D-R sequence are in good agreement with the LRO- LOLA lunar limb profile, except for the R1 event, which is clearly in error.

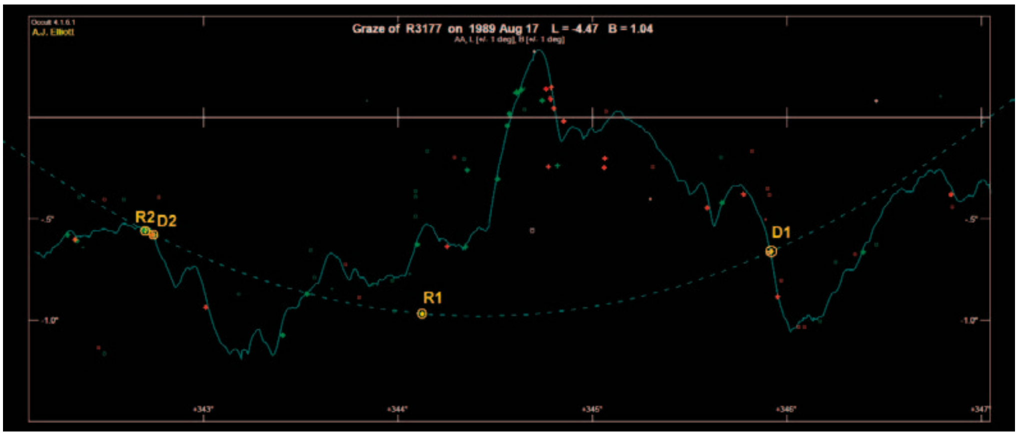


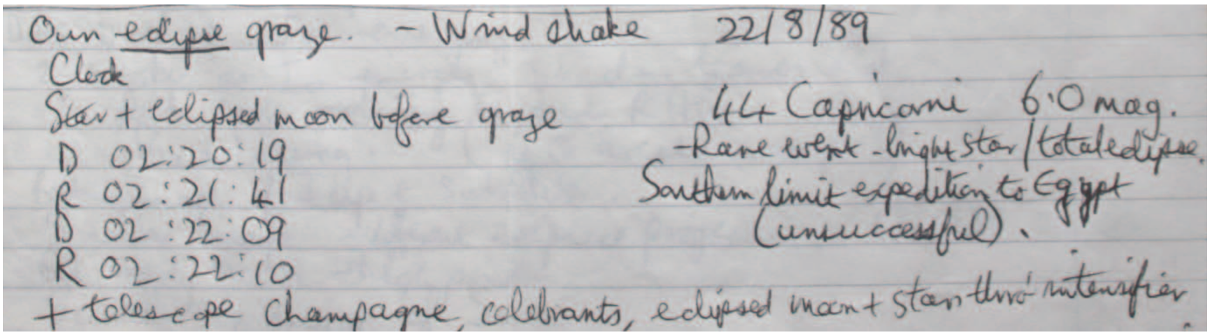
Figure 3: Lunar limb profile of Andrew's timings (Lunar Occultations Archive) using LRO-LOLA data (Occult).

This is confirmed by the computed O-Cs; they are generally small, but the R1 event has a large O-C of -0.45 (Table 1).

ref	Tel	Observer	Star	No.	y	m	d	h	m	s	PhGrMrCeDb	O-C	limb	PA	l	b	AA	P	D	scale
011	C	A.J. Elliott	R	3177	1989	8	17	2	20	19.68	DD G O 1	0.03	-0.73	328.23	-4.47	1.04	345.92	345.90	0.34	1.051
012	C	A.J. Elliott	R	3177	1989	8	17	2	21	21.52	RD G O 1	-0.45	-0.57	326.43	-4.47	1.04	344.12	344.11	0.49	1.051
013	C	A.J. Elliott	R	3177	1989	8	17	2	22	9.08	DD G O 1	0.00	-0.61	325.05	-4.47	1.03	342.74	342.74	0.60	1.051
014	C	A.J. Elliott	R	3177	1989	8	17	2	22	10.56	RD G O 1	-0.01	-0.58	325.01	-4.47	1.03	342.70	342.69	0.60	1.051

Table 1: Andrew's original timings (Lunar Occultations Archive) showing the large O-C for event R1 (Occult).

I am the custodian of Andrew's collection of VHS videotapes of asteroidal and lunar occultations, and meteor showers, etc, and I have his hand-written notes on this grazing occultation. Event R1 is listed in table 1 as occurring at 02:21:21.52 UTC, but in his notes he refers to it as taking place at 02:21:41 (figure 4).



Own eclipse graze. – Wind shake 22/8/89
Clock
Star + eclipsed moon before graze
D 02:20:19
R 02:21:41
D 02:22:09
R 02:22:10
+ telescope Champagne, celebrants, eclipsed moon + star thro' intensifier

44 Capricorni 6.0 mag.
-Rare event - bright star / total eclipse.
Southern limit expedition to Egypt
(unsuccessful).

Figure 4: Andrew's personal summary of the grazing occultation. Note that he inadvertently wrote the date as 22/8/89 instead of 17/8/89.

So, the Occultations Archive contains an erroneous record. As a test in Occult, I imported the observations from the Historical Grazes dataset and temporarily changed my copy of the R1 event to the corrected time of 02:21:41.52 and it gave a much reduced O-C of -0.02 (table 2), now in line with his other residuals and looking a much better fit on the graze profile (figure 5).

ref	Tel	Observer	Star	No.	y	m	d	h	m	s	PhGrMrCeDb	O-C	limb	PA	l	b	AA	P	D	scale
011	C	A.J. Elliott	R	3177	1989	8	17	2	20	19.68	DD G O 1	0.03	-0.73	328.23	-4.47	1.04	345.92	345.90	0.34	1.051
012	C	A.J. E lliott	R	3177	1989	8	17	2	21	41.52	RD G O 1	-0.02	-0.90	325.85	-4.47	1.04	343.54	343.54	0.53	1.051
013	C	A.J. Elliott	R	3177	1989	8	17	2	22	9.08	DD G O 1	0.00	-0.61	325.05	-4.47	1.03	342.74	342.74	0.60	1.051
014	C	A.J. Elliott	R	3177	1989	8	17	2	22	10.56	RD G O 1	-0.01	-0.58	325.01	-4.47	1.03	342.70	342.69	0.60	1.051

Table 2: The corrected timing, showing the much smaller O-C for the R1 event (Occult).

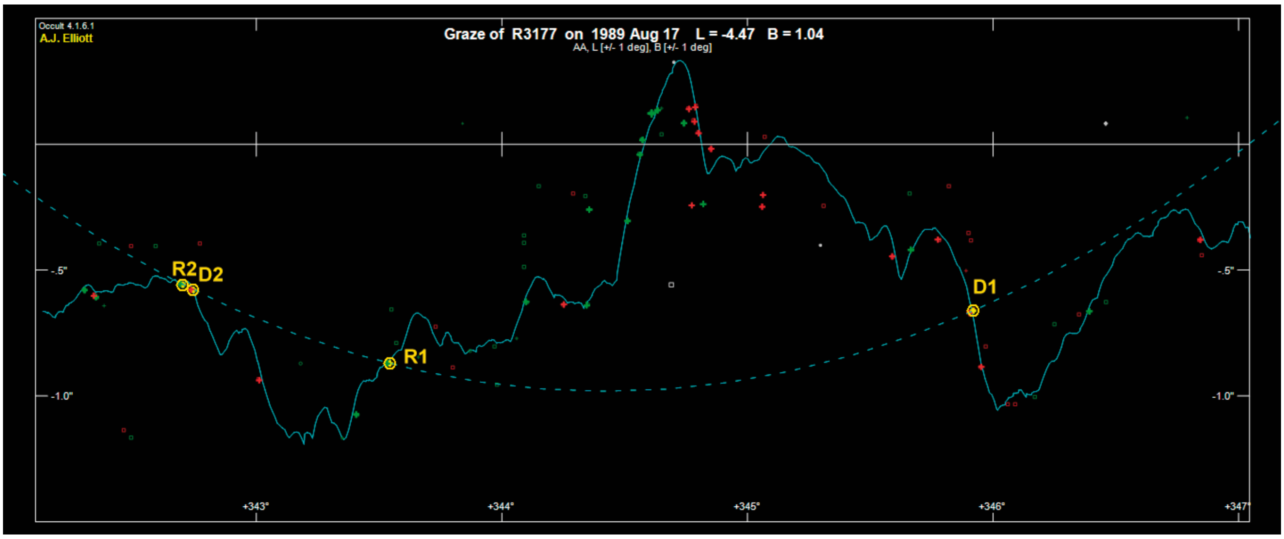


Figure 5: Lunar limb profile with the corrected timing (Occult).

Andrew Elliott

Eberhard Bredner and his wife

As an additional check, I reviewed Andrew's VHS tape of the grazing occultation, imported it to an AVI file on my laptop computer and it confirmed that the observation should have the timing 02:21:41.52 and not 02:21:21.52. A mistake was made either when the timings were reported by Andrew or when they were added to the Archive.

I notified Mitsuru Soma (Graze Coordinator) by e-mail and he updated the record in his dataset and he asked Dave Herald to correct it in the Lunar Occultations Archive (VizieR database in Strasbourg).[4] Dave Herald corrected the record in his main archive file, flowing through to the reductions file and it will appear in the Archive in due course.[5]

Andrew's video is a nice record of the grazing occultation and after making their successful observations he turned the camera towards his fellow celebrants as they toasted their success by drinking champagne, see figures 7 and 8.

Concluding remarks

If Tim Haymes had not made his valuable 2015 eclipse graze observations and published them in the BAA Lunar Section Circular we might never have found and corrected Andrew Elliott's erroneous timing from 1989.

This also illustrates the value of retaining original log books and recordings, although as the years pass by VHS tapes will slowly degrade (DV tapes much less so) and the equipment used to read them will become museum pieces.

We should consider transferring valuable recordings to long-term high-quality tape media and online storage, to try to future-proof such archival material.

Observers are responsible for checking the (asteroidal and lunar) occultations databases and archives to ensure that their timings and other details have been accurately recorded.

References

1 BAA Lunar Section Circular Vol 52, No 11, November 2015, pp. 18-21

2 Tim Haymes, e-mail, 2015 November 6

3 The graze observers were:- M. G. J. Gough, G. Tyler, A. J. Elliott, Eberhard Bredner, A. O. Miller, M. Brain, J. Meacham, Nes Brown, J. J. Howarth, A. O'Hare, K. Sheldon, A. Cockburn, S. Webb

4 Mitsuru Soma, e-mail, 2015 November 20

5 Dave Herald, e-mail, 2015 November 23

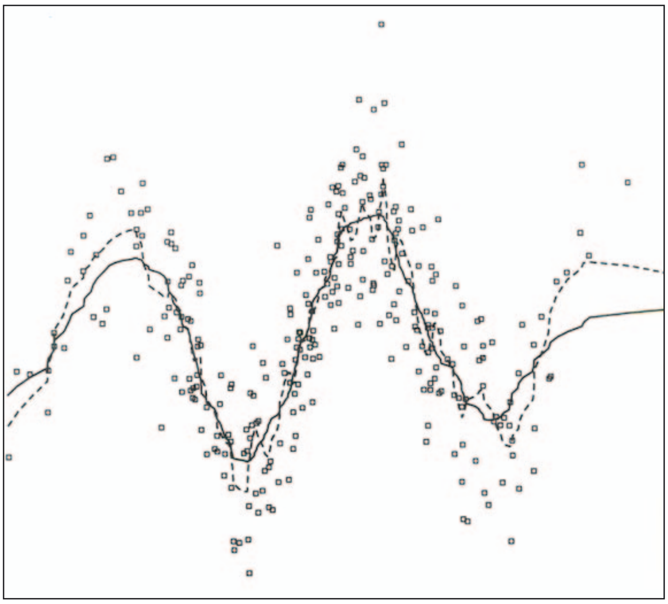
This Issue's OCCULTATION Tip:

Data-Reduction

In case you have some proposals to be presented by yourself or things you would like to know more about it: Please let us know.

by Helmut Jahns

In today's volume we discuss the de-noising of data. Noisy data in our sense means that a number of measured values has a certain degree of uncertainty that can be described by means of an error bar. There are several approaches how to smooth noisy data like that.

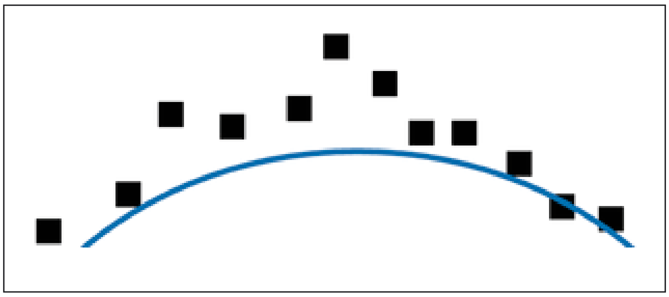


Picture: Example of a graph with noisy data (from Numerical Recipes) including two smoothing curves.

First one might want to generate an interpolation curve including each data point, e.g. by Cubic Splines. But because of our error bars we cannot assume our measure points to be precise, why interpolation proves to be useless.

Another very effective approach is a compensation curve to achieve the best fit of the data, e.g. by Polynomial Regression. But for this a data model is necessary like a function f(x)= …; this could be a square regression $f(x) = ax^2 + bx + c$. If such a theoretical data model does not exist this is no possible solution either. Without additional assumptions the data has to be smoothed by another method.

The simplest way is to average the data. The average is calculated within an interval of n measure points towards the right and left of each data point. But this has to be done with care: close to the extremes of a curve (local maximum or minimum) this method results in a flattening of the curve: the wider the interval, the flatter the maximum or minimum. Picture: The averaging of data (black squares) close to a maximum with an interval of e.g. 12 data points results in a flattening of the smoothed curve (blue). The smoothed curve as estimated by the eye runs above the averaged curve.



In "Numerical Recipes" (Press et al., see below) a different way to de-noise data is described that avoids the above shown restriction. For this a linear compensation curve within the raw data is formed and then subtracted from the raw data. The resulting data set undergoes a Fast Fourier Transformation (FFT) and is then processed by a low-pass filter. To obtain the smoothed curve the result is transformed back using FFT and the linear part is added. The amount of smoothing can be triggered by a parameter n correspondent to the data point interval to the right and left of a measure point where n does not have to be an integer.

Another aspect is dealing with the data points at the edges of the measure range. When for example to the right of a measure point the number of measure points is less than necessary for an interval of 2n the interval on the left side is widened by the same amount. This leads to constant smoothing at the edges. That procedure may not be ideal but results in a better fit than reducing the interval at the edges to fit the interval into the measure range and having a width of zero at the last measure point. That way the last value would be regarded to be precise even though it has an error.

The first edition of "Numerical Recipes" gives the source text of a function called smooft() that does precisely this kind of smoothing. Each but the most recent edition of the book is freely available on the internet. In the third edition this function was included in another one called convlv().

Literature: Press et al, Numerical Recipes in C/Pascal/Fortran,
1. Edition, Ch. 13.9: "Smoothing of data"

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

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