# Occultation Newsletter

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## FROM THE PUBLISHER

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| | |
|---|---|
| Local circumstance (asteroidal appulse) predictions | 1.00 |
| Graze limit and profile predictions (per graze) | 1.50 |
| Papers explaining the use of the predictions | 2.50 |

Asteroidal occultation supplements will be available at extra cost: for South America via Ignacio Ferrin (Apartado 700; Merida 5101-A; Venezuela), for Europe via Roland Boninsegna (Rue de Mariembourg, 33; B-6381 DOURBES; Belgium) or IOTA/ES (see below), for southern Africa via M. D. Overbeek (Box 212; Edenvale 1610; Republic of South Africa), for Australia and New Zealand via Graham Blow (P.O. Box 2241; Wellington, New Zealand), and for Japan via Toshio Hirose (1-13 Shimomaruko 1-chome; Ota-ku, Tokyo 146, Japan). Supplements for all other areas will be available from Jim Stamm (11789l N. Joi Drive; Tucson, AZ 85737; U.S.A.) for $2.50.

Observers from Europe and the British isles should join IOTA/ES, sending DM 40.-- to the account IOTA/ES; Bartold-Knaust Strasse 8; 3000 Hannover 91; Postgiro Hannover 555 829 - 303; bank-code-number (Bankleitzahl) 250 100 30.

## IOTA NEWS

David W. Dunham

ESOP XI: The 11th European Symposium on Occultation Projects will be held at Castle Gondolpho, Rome, Italy, August 28-30, 1992. The best grazing occultation in Europe during 1992 will occur that week, on Monday morning, August 24th, about 2/3rds of the way from Rome to Naples; the star is 2.8-magnitude Mu Geminorum (Tejat) and the graze will occur on the dark side near the north cusp of the 22% sunlit waning moon. The IOTA/USNO total occultation predictions for 1993 for European observers may be distributed to national coordinators at the meeting, as they were done for 1992 at ESOP X in Hannover last August (ON 5, #5, p. 109). Those wishing to give a presentation at, or otherwise suggest something for the agenda of, ESOP-XI should contact IOTA/ES president Hans Bode, Bartold-Knaust-Str. 8, D-W-3000 Hannover 91, Germany, telephone 49-511-424696. For more information, contact the ESOP XI organizer, Dr. Claudio Costa; Viale Colli Portuensi, 345; I-00151 Roma, Italy; telephones 39-6-4451105 (home) or -43602520 (office) or -4131133 (fax); E-mail (Internet): specola_vat%astrom.hepnet@Csa2.LBL.Gov.

IOTA/ES Astrometry Meeting: A meeting on asteroidal occultation astrometry will be held on Sunday, May 17, in Hannover, Germany; contact Hans Bode, phone 49-511-424696, for more information. The meeting will be mainly led by Mike Kretlow; see his and D. Boehme's article, "Last Minute Astrometry Network", in this issue.

IOTA Meeting: The next (10th) annual meeting of the International Occultation Timing Association will probably be held Saturday, 1992 October 3, in the Houston, Texas, area. See p. 129 of the last issue, especially about two grazes that occur the evening of October 1st (Don Stockbauer notes that there will probably not be time to travel between the two paths to observe both of them, and the 44 Ophiuchi graze will occur at such low altitude that a site at least 100 miles southwest of Houston may be needed to observe it). The location of the meeting has not yet been determined, but it and the meeting date and time will be announced in the next issue. The local coordinator will be Paul Maley; 11815 Lone Hickory Ct.; Houston, TX 77059; U.S.A.; telephone 1-713-4886871; E-mail (Decnet) sn::maley.

Reporting Occultation Observations on Diskette: Timings of both total and grazing lunar occultations can be reported to the International Lunar Occultation Center (ILOC) in Tokyo in ASCII files on floppy disks, using the format and instructions given in my article, "Let's Report Occultation Timings on Diskettes", in ON 4, #5, pp. 92-97. Doing this eliminates possible keypunch errors at ILOC and speeds up the return of timing residuals to you. One change is that we no longer have the Apple II+ computer, so that we can no longer perform the conversion specified in the article; all diskettes sent to ILOC should be IBM-compatible. Diskettes will not be returned by ILOC unless requested; also, I understand that, upon request, the residuals can also be returned on diskette, if large numbers of timings are involved.

Visit by Shanghai Observatory Astronomer: Dr. Qian Bochen, from Shanghai Observatory, obtained funding from the Chinese Academy of Sciences to stay in the U.S.A. to work with IOTA. IOTA doesn't have any office space or other assets to support such a visit directly. Arrangements were made, with Prof. Michael A'Hearn's help, to obtain an invitation from the Astronomy Program at the University of Maryland in College Park. He arrived at the end of February and will be here for 6 months. Dr. Qian has photoelectrically recorded lunar occultations, and one asteroidal occultation, at Shanghai Observatory. Shanghai Observatory has two portable 20-cm telescopes, which they used for recording Bailey's beads from both limits of the 1987 September annular eclipse, and which can be used for lunar grazing and asteroidal occultations. They also have astrometric telescopes, including a 155-cm reflector similar to USNO's 61-inch near Flagstaff, AZ, which has obtained the most accurate astrometry for asteroidal and planetary occultations to date. So a major purpose of Dr. Qian's visit is to obtain copies of my programs for calculating right ascension and declination residuals from astrometric observations, and computing improved asteroidal occultation paths from these updates. This gives further motive for me to make these programs transportable to small computers, which I need to do soon anyway for other reasons. Dr. Qian also is interested in videorecording occultations with portable equipment, and he has already seen this first-hand.

IAU Commission 20: The report by L. Wasserman, chairman of Commission 20's working group on occultations (by Solar System objects other than the Moon), was read at the International Astronomical Union's General Assembly held in August in Buenos Aires. During the past 3 years, major events noted involved Titan, 4 Vesta, 9 Metis, 216 Kleopatra, 381 Myrrha, and 521 Brixia; IOTA had heavy involvement with each of these occultations. Lief Kristensen announced that he would need to leave the working group, so a new European member is needed. Wayne Warren represented IOTA's interest at the meeting.

Unusual Telescopes is the title of IOTA member Peter Manly's new 200-page book published by Cambridge University Press, 40 West 20th St., New York, NY 10011-4211. Some of the designs were influenced by especially for portability.

Meta Research Bulletin Vol. 1, #1 was issued in mid-March. Tom Van Flandern, leader of last July's successful Eclipse Edge expedition to Mexico, is the editor of this new publication, which seeks to support and encourage research "into astronomical theories which are in accord with observations and experiment, add insight or understanding, and make testable predictions; but which are not otherwise supported because they lie outside of the mainstream of theories in astronomy." The first issue includes articles about a possible natural satellite of Phobos photographed by the Soviet Phobos-2 probe and an analysis of the apparent lack of satellites in the first Galileo photos of 951 Gaspra. The quarterly bulletin is available for $25/year from Meta Research, Inc.; P.O. Box 15186; Chevy Chase, MD 20815; U.S.A.

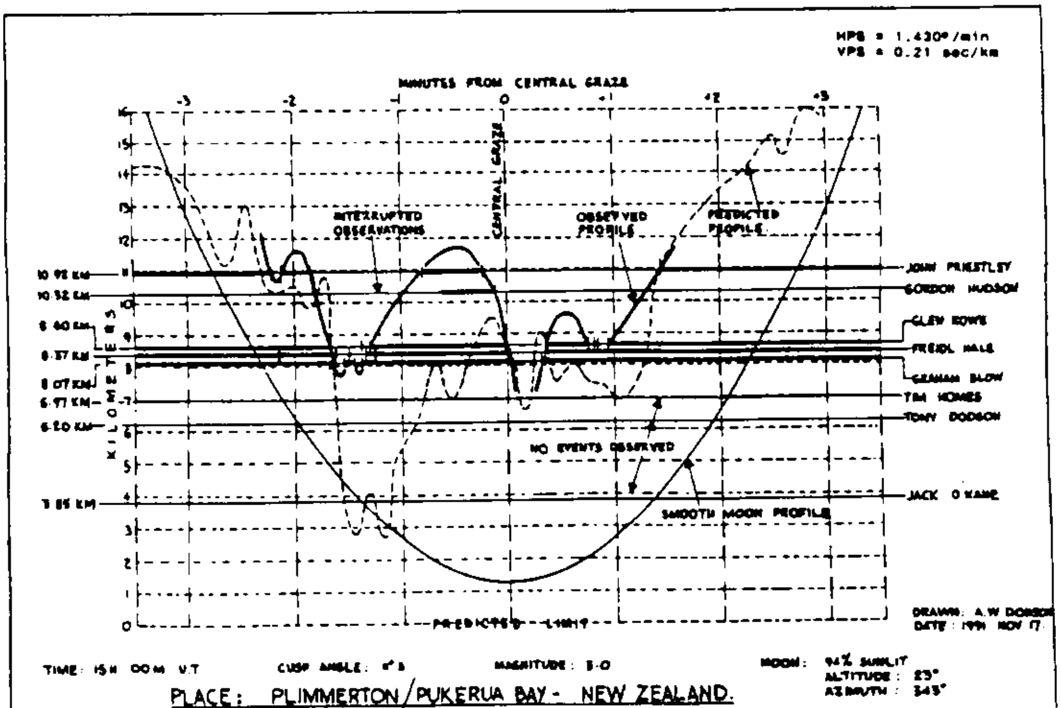
Next Issue: The next issue of ON (Vol. 5, #8) will be distributed in July; contributions should be received by June 27th. The issue after that (Vol. 5, #9) will be produced and distributed in October, after the U. S. Naval Observatory's IBM mainframe computer is shut down; see my article on lunar occultation predictions and software.

## GRAZING OCCULTATION REDUCTION PROFILES

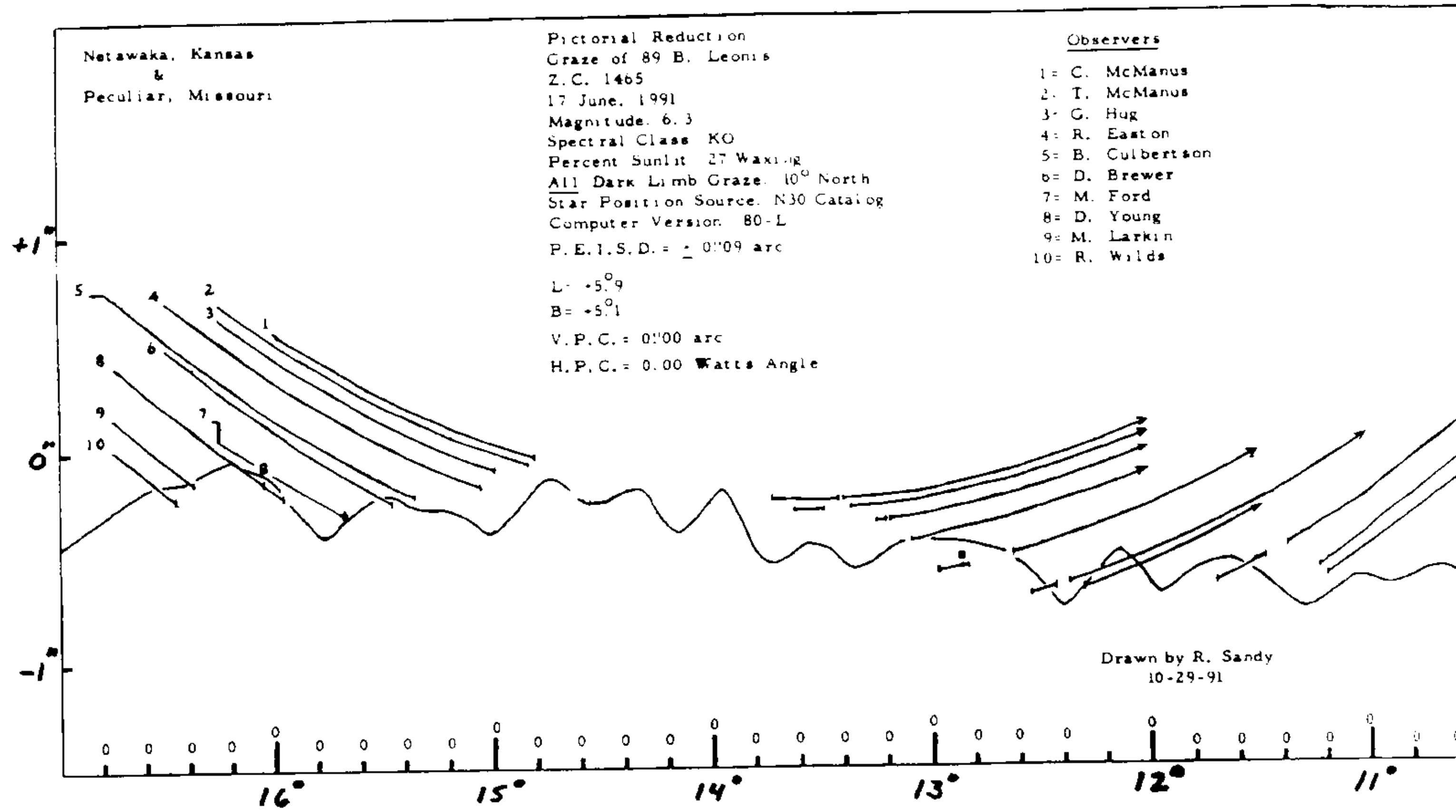
We have received reduction profiles from Bob Sandy of several grazes observed during the last few years. Some of the better events are reproduced on the next pages. Unlike the ACLPPP prediction profiles, where the paths seen by the observers are horizonal lines across the charts, these reduction profiles are drawn with the Moon's mean limb as a horizontal line, so that the paths followed by the observers are curved.

Profiles are included for grazes of ZC 1465 on June 17, 1991 and ZC 3186, observed on October 1, 1990. Both of these were observed in Kansas and Missouri. Also included is a plot of the Alcyone graze of October 25, 1991 published in the Royal Astronomical Soc. of New Zealand Occultation Section circular of April, 1992.

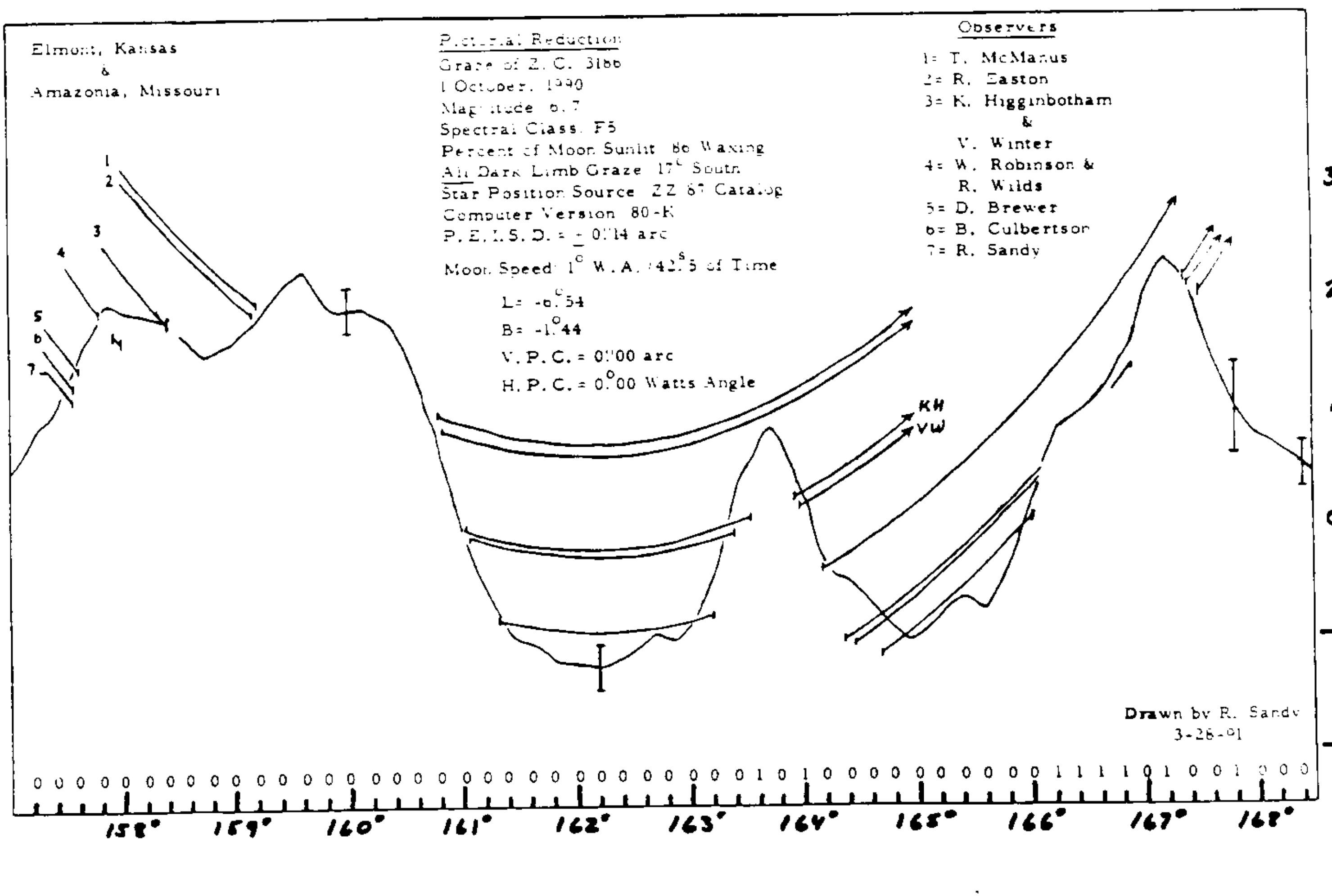
Robert Sandy is a well-known graze observer from Blue Springs, Missouri whose reduction profiles have been published in previous ON's.




Grazing Occultation of Star "ALCYONE" (Eta Tauri) - 1991 Oct 25



Netawaka, Kansas
&
Peculiar, Missouri
Pictorial Reduction
Graze of 89 B. Leonis
Z.C. 1465
17 June, 1991
Magnitude 6.3
Spectral Class KO
Percent Sunlit 27 Waxing
All Dark Limb Graze 10° North
Star Position Source N30 Catalog
Computer Version 80-L
P.E.I.S.D. = ± 0.09 arc
L= +5.9
B= +5.1
V.P.C. = 0.00 arc
H.P.C. = 0.00 Watts Angle
Observers
1= C. McManus
2= T. McManus
3= G. Hug
4= R. Easton
5= B. Culbertson
6= D. Brewer
7= M. Ford
8= D. Young
9= M. Larkin
10= R. Wilds
Drawn by R. Sandy
10-29-91
+1"
0"
-1"
16°
15°
14°
13°
12°
11°

Elmont, Kansas
&
Amazonia, Missouri
Pictorial Reduction
Graze of Z.C. 3166
1 October, 1990
Magnitude 6.7
Spectral Class F5
Percent of Moon Sunlit 86 Waxing
All Dark Limb Graze 17° South
Star Position Source ZZ 87 Catalog
Computer Version 80-K
P.E.I.S.D. = ± 0.14 arc
Moon Speed 1° W.A./42.5 of Time
L= -6.54
B= -1.44
V.P.C. = 0.00 arc
H.P.C. = 0.00 Watts Angle
Observers
1= T. McManus
2= R. Easton
3= K. Higginbotham
&
V. Winter
4= W. Robinson &
R. Wilds
5= D. Brewer
6= B. Culbertson
7= R. Sandy
KH
VW
Drawn by R. Sandy
3-28-91
158°
159°
160°
161°
162°
163°
164°
165°
166°
167°
168°

## GRAZING OCCULTATION OBSERVATIONS

Don Stockbauer

Due to the use of an inaccurate ephemeris for the 1990 graze predictions (see ON 5 (2), p. 34), 1990 shifts are not directly comparable to those of 1991 and should not be used to upgrade your current version 80K (or equivalent 80L) predictions.

Northern-limit dark-limb grazes during waxing crescent phases are shifting to the south from the present USNO predictions, on the average; see David's articles (ON 5 (3), p. 92), and in this issue. Similar south shifts have not been occurring systematically during the waning crescent phases.

After seven years of writing this article, I feel that it is time to pass on the job to someone new, due mostly to my developing several time-consuming non-occultation interests. Richard Wilds has graciously agreed to take over my responsibilities (accepting graze reports, compiling the quarterly lists, writing the accompanying articles, etc.). His address is:

Richard Wilds
3630 S.W. Belle Ave.
Topeka, KS 66614
USA

Please address all future graze reports and related correspondence to him. Remember to send copies of reports to the International Lunar Occultation Centre (ILOC) at: Geodesy and Geophysics Division; Hydrographic Department; Tsukiji-5, Chuo-ku; Tokyo, 104 Japan.

Thanks to everyone who filed reports over the years and best wishes to Richard.

Graze List 03/05/1992

| Date V YYMMDDP | Star Num | Mag | % Snl | CA | Location | # Sta | # Tm | S S | Ap Cm | Organizer | N ShS | WA | B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 890824 | 076547 | 80 | 44- | 7N | Ottawa,Ontario | 1 | 4 | 1 | 20 | Brian Burke | | 354 | -60 |
| 900202 | 0302 | 64 | 43+ | 6N | San Antonio,TX | 10 | 64 | 1 | 15 | Frankenbrgr/Dawes | 0 | 5 | -66 |
| 900208 | 1310 | 42 | 99+ | 4S | Gent-Drongen,Bel | 4 | 6 | 2 | 6 | R. de Bosscher | 1N | 188 | -5 |
| 900303 | 076046 | 75 | 38+ | 7N | Franktown,Ontar. | 4 | 30 | 2 | 10 | Brian Burke | 1N | 6 | -63 |
| 900306 | 1049 | 66 | 72+ | 13N | Ottawa,Ont. | 3 | 9 | 2 | 10 | Brian Burke | 3N | 15 | -33 |
| 900309 | 1396 | 71 | 94+ | 16N | Hoogstraten,Belg | 4 | 10 | 1 | 15 | P. Vingerhoets | 1N | 16 | 11 |
| 900401 | 078195 | 80 | 43+ | 11N | B.Compascuum,Net | 8 | 28 | 1 | 20 | Andy Benjamins | 3N | 12 | -38 |
| 900617 | 109145 | 72 | 40- | 8N | Izel,Belgium | 3 | 15 | 1 | 20 | Valentin Kinet | 2S | 352 | -48 |
| 900813 | 0387 | 69 | 56- | 7N | Roksem,Belgium | 4 | 14 | 1 | 12 | Herman Willaert | 0 | 353 | -62 |
| 910221 | 0553 | 68 | 48+ | 4N | Berlin,Germany | 6 | 22 | | 10 | Wolfgang Rothe | | | |
| 910404 | 2366 | 12 | 78- | 1S | Aranjuez,Spain | 3 | 16 | 2 | 20 | P. Vingerhoets | 1N | 183 | 54 |
| 910424 | 1519 | 65 | 76+ | 9N | Nieuwerker.,Belg | 5 | 8 | 1 | 15 | Jef Reynders | 2S | 7 | 54 |
| 910516 | 0936 | 59 | 10+ | 11N | Izel,Belgium | 10 | 83 | 1 | 8 | Valentin Kinet | 3S | 12 | -12 |
| 910617 | 1468 | 49 | 28+ | 8N | McAlester,OK | 2 | 7 | 1 | 6 | Daniel Johnson | | 11 | 52 |
| 910831V | 0440 | 46 | 66- | 7N | Sawdust,FL | 3 | 20 | 1 | 20 | Tom Campbell | 1S | 353 | -52 |
| 910901 | 0564 | 61 | 57- | 2N | Walsbets,Belgium | 11 | 35 | 1 | 11 | P. Vingerhoets | 0 | 358 | -44 |
| 910914V | 2251 | 75 | 32+ | 10S | Tarkington Pr,TX | 8 | 30 | 1 | 10 | Don Stockbauer | 0 | 171 | 56 |
| 910930 | 077375 | 71 | 60- | 0S | Alfebre Mar,Port | 2 | 2 | 2 | 15 | Joaquim Garcia | | 181 | -20 |
| 911002 | 1202 | 69 | 33- | 7S | Amazonia,MO | 2 | 14 | 1 | 15 | Robert Sandy | 0 | 188 | 18 |
| 911002 | 1202 | 69 | 33- | 6S | Nim City,NE | 2 | 4 | 1 | 33 | Richard P. Wilds | 3S | 188 | 18 |
| 911003 | 1323 | 63 | 24- | -2N | Raccoon Creek,PA | 3 | 13 | 2 | 15 | John Holtz | 0 | 2 | 32 |
| 911003 | 098080 | 89 | 25- | 7S | Poceirao,Port | 2 | 11 | 1 | 15 | Joaquim Garcia | 0 | 187 | 30 |
| 911004 | 098692 | 89 | 16- | 9S | Caxias,Port. | 1 | 3 | 1 | 20 | Joaquim Garcia | 5N | 187 | 44 |
| 911014 | 186284 | 84 | 34+ | 16S | Chester Town.,OH | 2 | 19 | 2 | 20 | Robert J. Modic | 3N | 164 | 21 |
| 911014 | 186332 | 85 | 34+ | 17S | Waller,TX | 8 | 32 | 1 | 18 | Don Stockbauer | 1S | 162 | 20 |
| 911019 | 145938 | 70 | 80+ | 18S | Keene,KS | 4 | 19 | 1 | 20 | Richard P. Wilds | 0 | 164 | -43 |
| 911113 | 163479 | 72 | 35+ | 17S | Pleasant Gap,MO | 2 | 8 | 2 | 15 | Robert Sandy | 0 | 162 | -19 |
| 911113 | 163479 | 72 | 35+ | 17S | Hepler,KS | 2 | 8 | 1 | 33 | Richard P. Wilds | 0 | 161 | -19 |
| 911117 | 3455 | 64 | 74+ | 13S | Sandusky,OH | 3 | 4 | 2 | 9 | Robert J. Modic | 3S | 170 | -60 |
| 911117 | 3501 | 53 | | | Itinomiya-Cho,Jp | 3 | 11 | | 6 | Mitsuo Kawada | | | |
| 911215 | 3524 | 69 | 57+ | 6S | Waterbury,NE | 2 | 1 | 1 | 33 | Richard P. Wilds | 7N | 175 | -65 |
| 911215 | 3524 | 69 | 57+ | 4S | Ashford,WI | 3 | 10 | 3 | 30 | G. Samolyk | | 178 | -65 |
| 911217 | 0317 | 64 | 82+ | 9S | Drebach,Germany | 1 | 6 | 1 | 15 | Andreas Viertel | 0 | 175 | -56 |
| 911229 | 157905 | 78 | 35- | 11S | Tucson,AZ | 1 | 20 | 1 | 20 | Jim Stamm | 14S | 189 | 70 |

## CORRECTIONS TO IOTA GRAZE PREDICTIONS

David W. Dunham

You should apply a southward correction of 0".3 to the predictions of northern-limit waxing-phase dark-limb grazes. An average correction of about this magnitude was noted for grazes under these circumstances during early 1991, and recent observations seem to confirm that it should still be applied this year. This has not been incorporated into the predictions, since a different correction (perhaps none) will be needed for 1993 graze predictions when we shift from the USNO OCC 80L system to Mitsuru Sôma's OCCRED program when producing ACLPPP profiles; see my article on occultation software. Note that, since the declinations of most stars in the XZ (especially those with position source ZZ87) are really accurate to only about ±0".3 (with some larger errors, in spite of the always-smaller value for the "probable error of star's declination" given in the IOTA graze prediction heading), the south shifts can be larger, and some recently-observed events have had 0 shifts.

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## FOR IMPROVED WWV RECEPTION

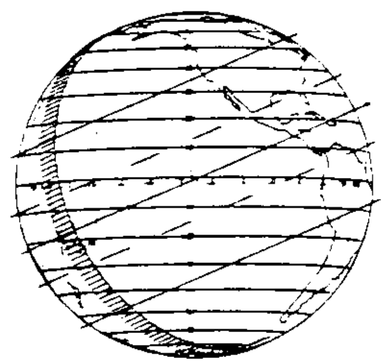
Dick Linkletter

Is your WWV signal fading and resuming strength as you listen? If so, check to see if your antenna is adequate. The typical buggy whip antenna on all-wave receivers and Radio Shack Time Kubes is all right for a strong signal in the absence of fading, but elementary practice in proper antenna design can improve reception when in trouble.

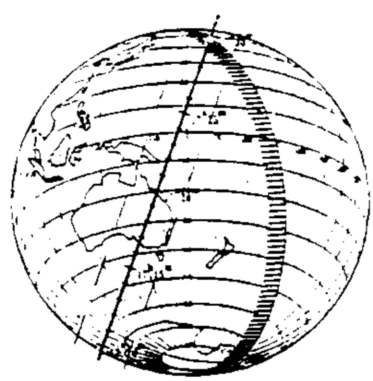
Since you doubtless have no way to tune a properly designed antenna to resonance, just use an improper antenna. It should be big enough to pick up plenty of energy from the fickle and flickering sky waves. Then, with no regard to impedance matching or polarization or even to some extent signal direction, it will outperform the typical 3 foot high buggy whip.

Simply stretch 25 to 50 feet of insulated wire, flexible preferred, in a direction approximately at right angles to the direction of WWV in Fort Collins, Colorado. Bare the end at your receiver and wrap it around the base of your buggy whip antenna. If fastidious you may attach it with a spring clip of good tight non chattering grip. Longer is better because it picks up more energy from crossing a larger region of space. Any length over ten feet should outperform the buggy whip and it improves almost as the square of the length. It should be above ground level if possible, using shrubs or tree branches for support. Jere Felten, W7TV-A, uses a bow and arrow to shoot the wire over a tree and make an inverted "V".

But you needn't be fancy; just stretch it out and compare with the whip performance. I hope this improves time recording for anyone in trouble.



20 Piscium by Mars 92 Apr 30



B23°74971 by Palisana 92 May 1

# OCCULTATION OF THE PLEIADES STAR CLUSTER BY THE MOON: A FIRST ANALYSIS

Adri Gerritsen and Ton Schoenmaker

In 1988 some favorable passages of the Moon through the well-known star cluster M45 were observed from The Netherlands. For the Dutch Occultation Association (DOA), these phenomena have been used as a test case for computer programs we wrote to predict and reduce stellar occultations of the Moon. Besides the values of the O-C's, we were also interested in the results when using different star catalogues. In this article, we discuss our method of computing O-C's and which star catalogue we consider to be the best for occultation work.

Since every observer of occultations wants to know his/her O-C as soon as possible after observing an occultation, the authors decided independently to write all software necessary for calculating an O-C. The major part of the programs were finished well before the first passage of the Moon through the star cluster, so it was possible to distribute accurate predictions. The observing campaign was announced in the Dutch amateur astronomy magazine Zenit, so a lot of potential observers could participate in this project.

Two separate software packages were developed. Ton Schoenmaker, programmer at the Kapteyn Observatory in Roden, The Netherlands, used a Digital Equipment VAX 11/750 minicomputer, and programmed in FORTRAN. The lunar positions were obtained from a magnetic tape supplied by Jet Propulsion Laboratory, with the LE200 positions of the Sun, Moon, and planets.

Adri Gerritsen used a small BBC-B micro-computer programmed in Assembly 6502 and BASIC. The lunar ephemeris was obtained by evaluating the shortened Meeus' version of Chapront's lunar theory ELP2000-82. Altogether over 6000 periodic terms were used, giving an accuracy of 0.01 arc seconds (0."01) in both lunar longitude and latitude. The coordinates of the Moon were transformed to the FK5 reference frame. The predictions for the particular events were based on the ELP2000-82 lunar theory and the XZ catalog version 80J.

After all 26 observers participating in the project received predictions for their locations, we starting looking forward to clear skies.....

Although the weather conditions were not excellent during the 1988 Pleiades passages (January 27th, August 6th, October 7th and December 20th), over 250 observations were made.

At this stage we decided to make separate reduction sets for all observations using the three well-known star catalogs; the SAO, AGK3, and XZ (version 80J).

Because the lunar coordinates from LE200 differed by less than 0"01 from those from the ELP2000-82 theory, the value of an O-C will not change significantly when changing from one source for lunar coordinates to another. Therefore, we expected that any discrepancy in our reduction set for one particular catalogue to be caused by errors in interpolating the Watts lunar limb data, a job we each performed separately.

Also, as any experienced observer will confirm, the glare of the Moon prevents us from making accurate timings of bright limb events, especially when the magnitude of the star is greater than 3.5. We calculated O-C's of bright limb events, but did not include them in the final analysis. Unfortunately, the events of the brightest Pleiades star, Alcyone (magnitude = 2.9), had to be excluded, since this star is not in the AGK3.

As soon as all observational data were received by the DOA, we started computing the O-C's. To do this, we had to

- convert the reported time (UTC) to UT1
- calculate the lunar ephemeris in the FK5 reference system (J2000.0)
- Calculate the apparent place of the star in the FK5 system

Converting a star's catalogue mean place into apparent position with respect to the true equinox of date involved applying the following corrections: Proper motion, equinox correction FK4-FK5, precession, nutation, and aberration.

When this task was completed, the coordinates of the observer were projected onto the fundamental plane, together with the positional data of the star and the Moon, making it possible to calculate the distance of the star to the mean lunar limb.

Finally, the Watts angle (corrected by +0°24) and both topocentric libration values were computed. The limb correction was taken from Watts' charts, corrected for the actual Earth-Moon distance, and added to the uncorrected smooth lunar limb O-C. This process was repeated for all observations.

The first conclusion that could be drawn confirmed our expectations: 25% of the 24 reported bright limb events had to be rejected, because the magnitude of their O-C's exceeded 2". On the other hand, all 227 dark limb events were well within this limit! For this reason, we decided to reject all bright limb events in the analysis (although we reported them to ILOC) because the timing errors involved seemed to be too large.

After all O-C values had been computed, their distribution should be plotted in a histogram of raw data, dividing the range between + and - 2" into bins of 0"2 width and finding the number of O-C's in that bin. The histogram plot is shown in Figure 1. If we study these pictures, it seems that all three catalogues are equally accurate, because their standard deviations are almost the same.

| Catalog | Standard Deviation of the "raw data" |
|---|---|
| SAO | 0".55 |
| AGK3 | 0.54 |
| XZ | 0.55 |

At first sight this is a somewhat surprising result, because the SAO star catalog is notorious for its bad proper motions and we therefore would have expected it to be the worst. What happened? The solution is quite simple: we should not merge the distribution of O-C's from both disappearances and reappearances if we are trying to analyze the standard deviation (accuracy) of a particular catalogue.

Let's assume, for example, that we have at our disposal two catalogues, A and B, star catalogue B being more accurate (smaller standard deviations) but subject to a systematic error of 1" in right ascension toward the East (i.e., all positions are approximately 1" too small). When we use catalogue A in our reduction program, we will find the mean values of the O-C's to be zero (no systematic errors) whereas catalog B will have two peaks in its O-C distribution: one peak near +1" (disappearances) and one near -1" (reappearances) [Note that this is converting residuals in time to residuals in position relative to the Moon's center. Ed] Because catalog B is more accurate, we would expect a smaller standard deviation, but as a result of the two maxima, the standard deviation is rapidly increasing; in fact it has become a function of any systematic error.

A way to overcome these possible systematic errors is to fit the residuals with a least-squares solution to the following equation:

$$\cos(K-R)*(0.549*\delta\triangle T + \delta L) - \sin(K-R)*\delta B - S = 0$$

where

$K - R$ = the angle between the point of occultation and the direction of the Moon's motion in the fundamental plane

$S$ = the O-C in arc seconds

$\delta\triangle T)$ = the uncertainty in Delta-T (Ephemeris Time minus Universal Time)

$\delta L$, $\delta B$ = the unknown corrections to the lunar ecliptic longitude and latitude, respectively

Since an exact value for dT was known for the times of the occultations, the equation can be rewritten as

$$\cos(K - R)*\delta L - \sin(K - R)*\delta B - S = 0$$

Solving for $\delta L$ and $\delta B$ with a least-squares solutions for each of the three catalogues gave us the following results:

| | | |
|---|---|---|
| SAO | $\delta L$ | $= +0''.29 \pm 0''.04$ |
| | $\delta B$ | $= +0.15 \pm 0.06$ |
| AGK3 | $\delta L$ | $= +0.12 \pm 0.04$ |
| | $\delta B$ | $= +0.16 \pm 0.07$ |
| XZ | $\delta L$ | $= +0.49 \pm 0.03$ |
| | $\delta B$ | $= +0.10 \pm 0.04$ |

Although the values are rather small, it is obvious that we are dealing with significant systematic errors of several tenths of an arc second. What are the sources? There are several possibilities:

- radius of the Moon error
- error in the lunar ephemeris
- errors in the positions of the Pleiades
- errors in the visual timings
- errors in the lunar limb profile.

An error in the value used for the radius of the Moon is not the source, since any error in the radius is independent of the angle (K - R). In other words, an error in the radius would cause the mean of the O-C's to increase, but the values of dL and dB should both be nearly zero.

The lunar ephemeris is known to very high accuracy (several inches, thanks to lunar laser ranging), so it is not the likely source. An error of 0''.5 corresponds to about 1 kilometer at the Moon's distance. Even the shortened Meeus' version is accurate to 0''.01.

Systematic errors of about 0''.5 in the Pleiades are also unlikely. Individual star positions might be in error by that much or more, but the systematic error should be much smaller.

Timing errors large enough to produce an error of 0''.5 would have to be 1 second of time ($1^s$). Again, while an individual error may be that large, the systematic errors should be smaller.

After reading several papers on this subject, we found the solution to our problem. Morrison and Appleby describe the fact that the centre of figure for the Moon (which occultations observe) does not coincide with the centre of mass of the Moon (which the lunar ephemeris predicts.) Their article, "Analysis of Lunar Occultations" appeared in the M.N.R.A.S, 1981, vol 196, pp 1013-1020. This gave us an important clue, since Watts intended the position of his datum in longitude to be consistent with the centre of figure. Using laser altimetry data from Apollo 15, 16, and 17, Sjogren and Wollenhaupt (1976) found that the centre of figure leads the centre of mass by about 0''.5, depending on the values of libration. They also noticed that this value could be 0''.2 in error in the present context. They also noticed some other corrections due to the ellipticity of the datum, but as they are small (less than 0''.1) they are not as important for our analysis.

In practice, this error means that we have to correct the Watts profile to put the observations observed relative to the Watts limb into agreement with the ephemeris. And this meant that we had to redo the reduction procedure once more with new limb data.

The distribution of the corrected O-C values is shown in the figures called "corrected for systematic errors". And what a surprising result we get: although the SAO and AGK3 catalogues seem to have the same accuracy (standard deviation of 0''.48 and 0''.52, respectively), the XZ version 80J Catalog has by far the lowest value: 0''.35!

If we repeat the entire procedure for all catalogues and distinguish between disappearances (148 timings) and reappearances (103 timings), corrected for systematic errors, we find the following values for the standard deviations:

| Cat. | Dis. | Rea. | D&R |
|---|---|---|---|
| SAO | 0″46 | 0″51 | 0″48 |
| AGK3 | 0.46 | 0.60 | 0.52 |
| XZ | 0.28 | 0.43 | 0.35 |

These figures are quite conclusive: The XZ has the lowest standard deviation of all, and we therefore may state that it is the most suitable catalogue of the three for occultation work. Another remarkable, although not unexpected, result is that the disappearances have a standard deviation that is 0″1 (approximately 0$^s$2) less than those of reappearances. This could be explained by the star not being visible until the moment of reappearance, making it more difficult for inexperienced observers to estimate the location on the lunar limb where the star will emerge. This effect results in less accurate estimated personal equations and consequently less accurate reported timings.

We assumed the values for standard deviation, as mentioned above, to be the values for the particular catalogue itself. However, this is not true. It can be shown that the standard deviation of a catalogue is less than the one we calculated, because this value is composed of catalogue, timing, and lunar limb errors:

$$\sigma(tot)^2 = \sigma(cat)^2 + \sigma(time)^2 + \sigma(limb)^2$$

In order to calculate the σ(cat), we need to know more about the σ(time) and the σ(limb). One method is to determine the σ(tot) from a series of observations of the same star. If we only consider the stars with at least 5 observations, we find a mean total error of 0″21. Because all the observations are of the same star, the error in star position is the same for all observers. Therefore, the σ(cat) is zero. We may then compute the errors as

$$\sigma(time)^2 + \sigma(limb)^2 = (0''21)^2$$

For a number of observations of the same star, the lunar limb corrections and their errors will be nearly the same for all observers in The Netherlands. This means that there will be a strong correlation between these limb correction data and their errors, so the value of 0"21 must be considered an underestimate. The standard deviation of the catalogs will consequently be less than the values given here:

| Catalog | σ(cat) (upper limit) |
|---|---|
| SAO | 0″43 |
| AGK3 | 0.48 |
| XZ | 0.28 |

Summarizing some of the major results of our analysis:

- The Pleiades passages of the Moon were 1$^s$ ahead of the predicted time. This could be explained by the centre of mass not coinciding with the centre of figure of the Moon.

- The correction to be applied to the lunar longitude and latitude in order to bring our ephemeris into agreement with the observed occultation phenomena agrees very well with the values found by Morrison and Appleby.

- The XZ catalogue is, compared to the SAO and the AGK3, by far the best catalogue for occultation work.

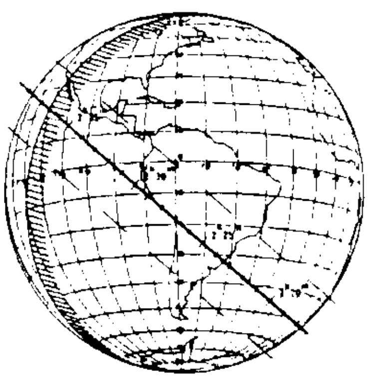
We would like to thank all observers for their efforts to make this experiment successful. Special thanks to Jean Meeus, Edwin Goffin, David Dunham, Bureau des Longitudes, and the Jet Propulsion Laboratory for their help in supporting us with the XZ catalogue (version 80J) and lunar theories.

<u>Dutch Occultation Association</u>

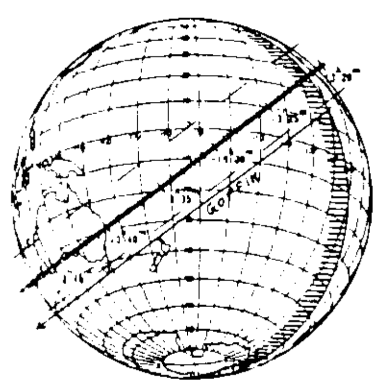
In 1948, a group of active amateurs established the N.V.W.S. Werkgroep Sterbedekikigen (WSb). Their main goal was to distribute predictions of total occultation phenomena and collect the observed data. In the late seventies, the first successful grazing occultation expeditions became reality, some of them with results published in scientific magazines. Today, the DOA consists of 70 members who have specialized in observing lunar occultations and grazes, occultations by asteroids, and eclipses of Jupiter's Galilean satellites. The results are published in the magazine <u>Occultus</u>, issued by the DOA four times a year.

In 1987 both authors, coordinators for grazing and total occultations in The Netherlands, respectively, started some software projects that resulted in several computer programs, including the reduction of total occultations by the Moon and the prediction and reduction of grazing occultations. The prediction and reduction of the Galilean satellite phenomena are also carried out on our own computers. The BBC-B computer mentioned in the article has been replaced by a very powerful Atari Mega ST4 with a co-processor, 4MB RAM, and a 120 MB hard disk. It is used for very detailed grazing occultation predictions, especially those for The Netherlands, Belgium, and Germany.

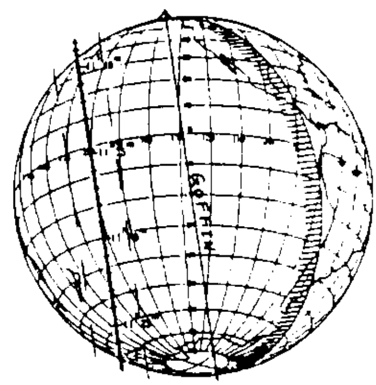
In 1993 the European Symposium of Occultation Projects ESOP XII will be organized by the Dutch Occultation Association. We hope to welcome you to The Netherlands!



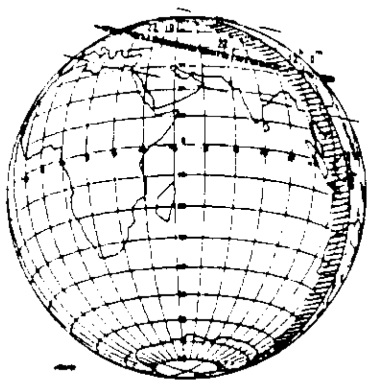
Psi Vir by Lotis 92 May 6



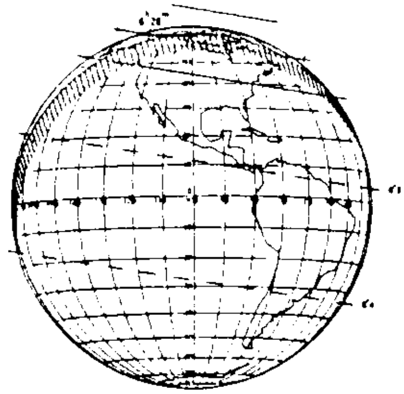
SAO 185362 by Scheila 92 May 12



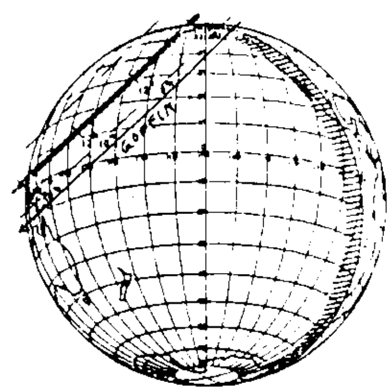
-20°5240 by Palisana 92 May 15



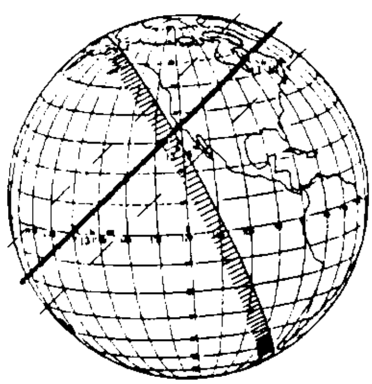
B17°48615 by Polyxo 92 May 19



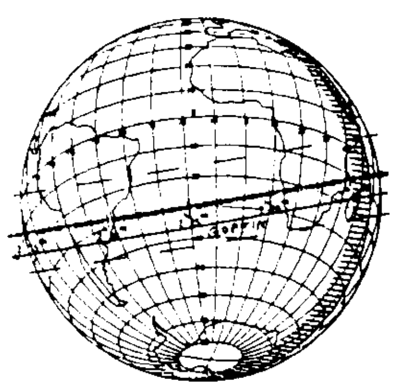
P 17 by Pluto 92 May 21



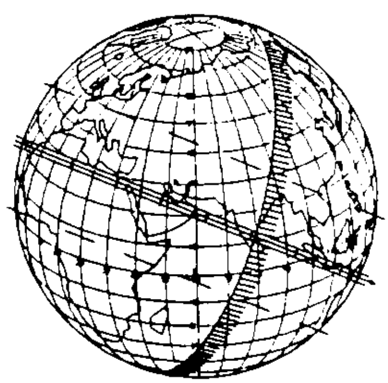
B17°52053 by Chloris 92 May 24



SAO 107217 by Artemis 92 May 27



SAO 185892 by Andromache 92 May 30



Anonymous by Davida 92 Jun 2

**Figure 1: Distribution of the Raw Residuals**

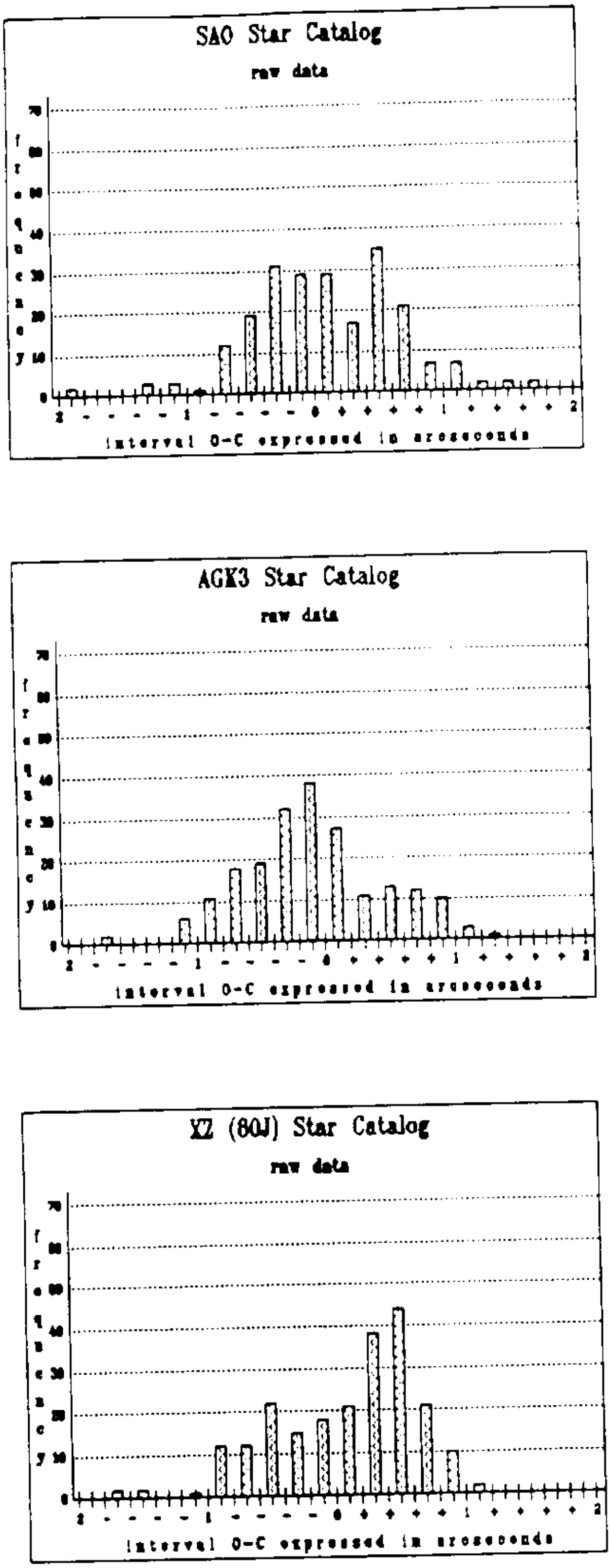
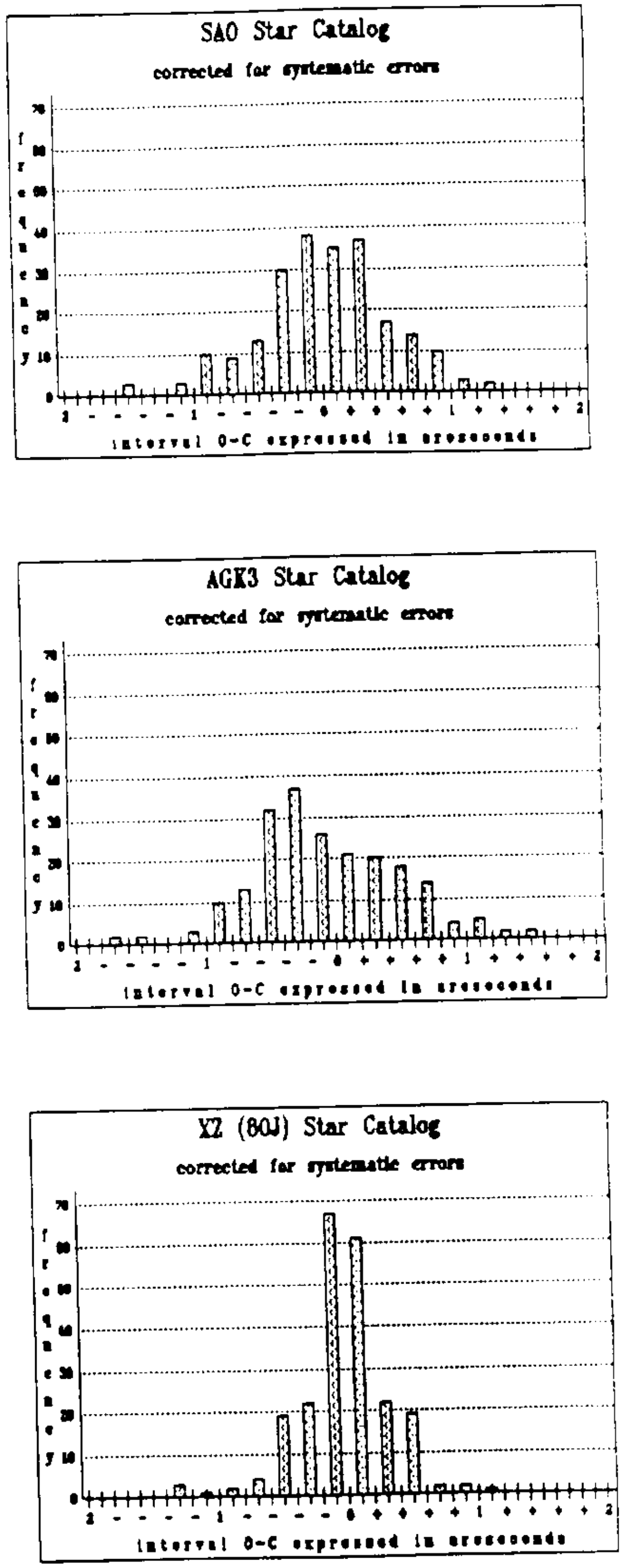



**Figure 2. Distribution of the Corrected Residuals**



# REPORTS OF ASTEROIDAL APPULSES AND OCCULTATIONS

Jim Stamm

If you do not have a regional coordinator who forwards your reports, they should be sent to me at: 11781 N. Joi Dr. Tucson, AZ 85737 USA. Names and addresses of regional coordinators are given in "From the Publisher" on *Occultation Newsletter's* front page. All times in this report are UTC.

Correction: [O.N. 5(4), p.93] (3) Juno and AGK3 -01° 1862; June 15 should be ....July 15.

I have summarized all of the reports that I have received for the first half of 1990 in the following two tables and section of notes. Table 1 lists the 1990 date, minor planet, occulted star, IDs of successful observers, and references to any notes. Table 2 lists the observer's ID, name, nearest town to location of observation, country (includes state or province for North America and Australia), and the total number of observations made in the period. The notes section details those events that included positive observations, or other significant information that could not be reported in the tables. I am not including notes on those observations that may have been spurious unless there is some sort of confirmation, or the fact that something may have happened is relevant to another observation. Instead, I will place an asterisk (*) in the Note column to indicate that I have received a report with more than a "no event....." in it.

Table 1. Asteroidal appulses and occultations: Jan-Jun 1990.

| 1990 | Minor | Planet | Catalog | Star | Observers | Note |
|---|---|---|---|---|---|---|
| Jan 01 | 150 | Nuwa | AC | 1051 | StaManPal | |
| Jan 02 | 696 | Leonora | AGK3+17° 0958 | | Khl | |
| Jan 08 | 404 | Arsinoe | AGK3+27° 0715 | | FoxMilScw | |
| Jan 10 | 1 | Ceres | FAC | 141146 | Ven | |
| Jan 16 | 566 | Stereoskopia | LickV | 1691 | StaFreLer VenManPal | * |
| Jan 18 | 410 | Chloris | AGK3+17° 0396 | | OveWacMitSmi GadMudMcr | |
| Jan 28 | 1459 | Magnya | AGK3+18° 1168 | | Blk | |
| Jan 31 | 83 | Beatrix | AGK3+00° 1595 | | OveSmiWac | |
| Feb 04 | 93 | Minerva | C29 | 13862 | Ove | |
| Feb 05 | 153 | Hilda | SAO | 157376 | KloLyzDwd | |
| Feb 15 | 30 | Urania | AGK3+15° 0185 | | BniCvgOveKni LeaFrzCorTol TjiSmiMcr | |
| Feb 25 | 1214 | Richilde | AGK3+22° 0696 | | VenJacWeiCon | |
| Mar 05 | 481 | Emita | LickV | 8224 | OveGesVnb | |
| Mar 10 | 628 | Christine | AGK3+24° 1113 | | LoaHutAndSmc | |
| Mar 11 | 444 | Gyptis | AGK3+11° 0739 | | | 1 |
| Mar 13 | 584 | Semiramis | AGK3+18° 0627 | | DssMddBulWet TruDwdWrr | 2 |
| Mar 13 | 78 | Diana | AGK3+24° 0889 | | | 3 |
| Mar 13 | 83 | Beatrix | AGK3+01° 1465 | | | 4 |
| Mar 18 | 39 | Laetitia | LickV | 12524 | | 5 |
| Mar 25 | 165 | Loreley | AGK3+16° 0869 | | BulDssEllGrc NelBrrHll | |
| Mar 29 | 358 | Apollonia | LickV | 23467 | NesBlkStgSto GriRolAnd | |
| Apr 02 | 431 | Nephele | SAO | 163445 | LoaPurBlkDik | |
| Apr 03 | 203 | Pompeja | AGK3+10° 1313 | | Vnb | |
| Apr 04 | 153 | Hilda | SAO | 138614 | LoaBlkDal | |
| Apr 13 | 397 | Vienna | SAO | 137402 | DssHllKocMbs MitGadVnb | |
| Apr 21 | 345 | Tercidina | SAO | 159545 | PriAnd | |
| Apr 22 | 161 | Athor | SAO | 183899 | Ove | |
| Apr 22 | 63 | Ausonia | AGK3+27° 0615 | | And | |
| Apr 27 | 62 | Erato | LickV | 11514 | StoLegMoaAnd | |
| Apr 28 | 78 | Diana | AC | 7040 | And | |
| May 02 | 89 | Julia | AGK3+27° 0667 | | BdwDssKkn PkzSyk | |
| May 03 | 38 | Leda | SAO | 146135 | DnzOveVnbMit | |
| May 08 | 766 | Moguntia | SAO | 207293 | PriBlwGriRolAnd | |
| May 10 | 535 | Montague | AGK3+15° 1209 | | HutAnd | |
| May 10 | 93 | Minerva | SAO | 211943 | BlkDalGem | 6 |
| May 15 | 388 | Charybdis | SAO | 146669 | OveVicMitSmi | |
| May 15 | 554 | Peraga | SAO | 158578 | BlkLoa | |
| May 16 | 106 | Dione | SAO | 139390 | DikLoa | |
| May 18 | 41 | Daphne | AGK3+02° 2405 | | GemHutAnd | |
| May 27 | 287 | Nephthys | SAO | 145660 | Blk | |
| May 30 | 88 | Thisbe | SAO | 184196 | OveSmiFrzMcr HutAnd | |
| Jun 06 | 8 | Flora | SAO | 161981 | Blk | |
| Jun 10 | 86 | Semele | SAO | 187211 | And | |
| Jun 14 | 476 | Hedwig | AGK3+01° 1266 | | WeiMas | |
| Jun 16 | 476 | Hedwig | AGK3+01° 1269 | | StaWeiMas | * |
| Jun 16 | 86 | Semele | B25 | 64292 | StgSmcAnd | |
| Jun 28 | 55 | Pandora | SAO | 207573 | DikStgSmc HutAnd | |

Table 2. Observers and locations of events: Jan-Jun 1990.

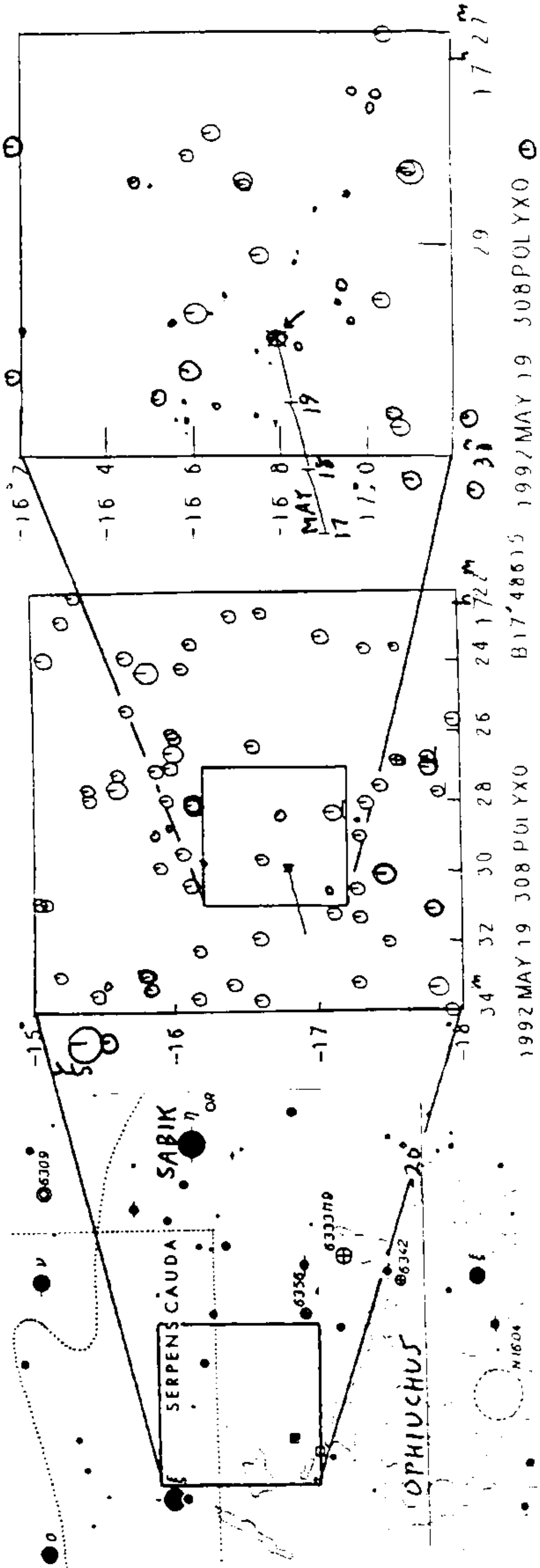
| ID | Observer | Town | Country | No. |
|---|---|---|---|---|
| And | Anderson, Peter | The Gap | Queensland - Aus. | 17 |
| Bni | Baroni, Sandro | Milano | Italy | 1 |
| Bff | Baruffetti, P. | Massa | Italy | 2 |
| Bdw | Benedyktowicz, L | Kracow | Poland | 2 |
| Brt | Bertoli, Oreste | Alpignano | Italy | 1 |
| Blk | Blanksby, Jim | Wandin | Victoria - Aus. | 9 |
| Blw | Blow, Graham | Wellington | New Zealand | 1 |
| Bkw | Borkowski, M. | Lodz | Poland | 1 |
| Brr | Borras, Vincente | Benicarlo | Spain | 1 |
| Idb | Bruce, Ian | Maidenhead, Berk. | United Kingdom | 1 |
| Bul | Bulder, Henk | Zoetermeer | Netherlands | 3 |
| Cas | Casas, Ricard | La Laguna, Tener. | Spain | 1 |
| Cvg | Cavagna, Marco | Sormano | Italy | 2 |
| Con | Connor, Steve | Brooklyn | Wisconsin - USA | 1 |
| Cor | Corderley, G, | Johannesburg | South Africa | 1 |
| Dal | Daalder, Peter | Launceton | Tasmania | 2 |
| Dbn | De Benedetto, G. | Reggio Calabria | Italy | 1 |
| Dnz | Denzau, Helmut | Essen | Germany | 1 |
| Dlr | Di Luca, Roberto | Bologna | Italy | 1 |
| Dik | Dickie, Ross | Gore | New Zealand | 7 |
| Dwd | Dunham, David W. | Greenbelt | Maryland - USA | 2 |
| Dss | Dusser, Raymond | Kalaa Sghira | Tunisia | 7 |
| Ell | Elliott, A.J. | Reading | United Kingdom | 3 |
| Fox | Fox, Tom | Columbus | Texas - USA | 1 |
| Frz | Frazer, B. | Johannesburg | South Africa | 2 |
| Fre | Freeman, Tony | Ferndale | California - USA | 1 |
| Frd | Friedlingstein,C | Bruxelles | Belgium | 1 |
| Grc | Garcia, Joaquim | Lisboa | Portugal | 3 |
| Gad | Garde, T. | Shurugwe | South Africa | 2 |
| Gen | Genovese, Marco | Torino | Italy | 1 |
| Gem | George, Martin | Launceton | Tasmania | 3 |
| Ges | Geyser, M. | Pretoria | South Africa | 1 |
| Glz | Gonzalez, Victor | San Martias | Spain | 1 |
| Gri | Grida, Joe | Aberfoyle Park | S. Australia-Aus. | 3 |
| Gdi | Gualdoni, Carlo | Sormano | Italy | 1 |
| Tvh | Haymes, Tim V. | Reading | United Kingdom | 1 |
| Her | Hernandez, Jose | San Martias | Spain | 1 |
| Hff | Hoffman, Martin | Weidenbach | Germany | 1 |
| Hll | Hollis, Andrew | Northwich | United Kingdom | 2 |
| Hut | Hutcheon | Sheldon/Warwick | Queensland - Aus. | 7 |
| Iel | Ielo, Antonio | Reggio Calabria | Italy | 2 |
| Jac | Jacobs, Tom | Brooklyn | Wisconsin - USA | 1 |
| Jst | Jahn, Jost | Bodenteich | Germany | 1 |
| Klo | Klos, Daniel | Brillion | Wisconsin - USA | 1 |
| Kni | Knight, J. | East Rand | South Africa | 1 |
| Koc | Kocsis, Antal | Balatonkenese | Hungary | 2 |
| Khl | Kohl, Mike | Wald | Switzerland | 3 |
| Kkn | Kosa-Kiss, A. | Salonta | Romania | 1 |
| Kru | Kruijshoop, A. | Mt. Pleasant | Victoria - Aus. | 1 |
| Lap | Larkin, Patricia | The Basin | Victoria - Aus. | 2 |
| Lea | Learmonth, R. | East Rand | South Africa | 1 |
| Ler | Lee, Ron | Falcon | Colorado - USA | 1 |
| Leg | Legg, Jonathon | Modbury North | S. Australia-Aus. | 1 |
| Loa | Loader, Brian | Black Birch/ Christchurch | New Zealand | 5 |
| Lyz | Lyzenga, Greg | Table Mt. | California - USA | 1 |

Tab.2 (Cont.). Observers/locations of events: Jan-Jun '90.

| | | | | |
|---|---|---|---|---|
| Man | Manly, Peter | Central | Arizona - USA | 2 |
| Mas | Manske, Bob | Brooklyn | Wisconsin - USA | 2 |
| Mcr | McRae, A. | Rustenburg | South Africa | 3 |
| Mdd | Middleton, R.W. | Brightlingsea, | United Kingdom | 1 |
| Mit | Mitchell, H. | Pennington | South Africa | 4 |
| Mil | Mitchell, Larry | Columbus | Texas - USA | 1 |
| Mln | Morillon, Eric | Liguge | France | 1 |
| Moa | Morton, A. | Modbury North | S. Australia-Aus. | 1 |
| Mos | Mostefaoui, T. | Alger | Algeria | 2 |
| Mot | Mottram, Ken | Toowoomba | Queensland - Aus. | 1 |
| Mud | Mulder, M. | Thabazimbi | South Africa | 1 |
| Nel | Neel, Regis | Venissieux | France | 2 |
| Nes | Nelson, Peter | Korrumburra | Victoria - Aus. | 2 |
| Otd | Obs.. Del Teide | La Laguna, Tener. | Spain | 1 |
| Ove | Overbeek, Danie | East Rand | South Africa | 9 |
| Pal | Pailer, Leroy | Central | Arizona - USA | 2 |
| Paj | Park, J. | Melbourne | Victoria - Aus. | 1 |
| Ptk | Pasternak, D. | Niepolomice | Poland | 1 |
| Pkz | Piskorz, Withold | Kracow | Poland | 1 |
| Poh | Posch, Thomas | Graz | Austria | 1 |
| Pri | Priestley, John | Pukerua Bay | New Zealand | 2 |
| Pur | Purvinskis, R. | Ashburton | New Zealand | 1 |
| Jcr | Rippington, John | Maidenhead, Berk. | United Kingdom | 1 |
| Rol | Rowell, Lyn | Aberfoyle Park | S. Australia-Aus. | 3 |
| Snz | Sanchez, Javier | S. Cruz de Tener. | Spain | 1 |
| Scr | Scandura, Marco | Massa | Italy | 1 |
| Scw | Schweers, Carl | Ardmore | Oklahoma - USA | 1 |
| Skk | Skalski, J. | Niepolomice | Poland | 1 |
| Syk | Slusarczyk, J. | Niepolomice | Poland | 3 |
| Smi | Smit, J. | Pretoria | South Africa | 5 |
| Smc | Smith, Charlie | Woodridge | Queensland - Aus. | 10 |
| Stg | St. George, Lou | Auckland | New Zealand | 4 |
| Sta | Stamm, Jim | Tucson | Arizona - USA | 3 |
| Sto | Stoeckeler, Ralf | Lyndoch | S. Australia-Aus. | 3 |
| Sza | Szabo, Sandor | Boly | Hungary | 2 |
| Szk | Szarka, Levente | Kecskemet | Hungary | 1 |
| Tji | Tjirkali, H. | Johannesburg | South Africa | 1 |
| Tol | Toldo, D. | Johannesburg | South Africa | 1 |
| Tbz | Trebacz, A. | Niepolomice | Poland | 2 |
| Tre | Tregaskis, Bruce | Mt. Eliza | Victoria - Aus. | 1 |
| Tru | Trueblood, Mark | Potomac | Maryland - USA | 1 |
| Dty | Tyler, Dave | Maidenhead, Berk. | United Kingdom | 1 |
| Vnb | VanBlommestein,P | Simon's Town | South Africa | 4 |
| Ven | Venable, Roger | Wrens/Ft. Gordon | Georgia - USA | 3 |
| Vic | Vincent, J. | Harare | South Africa | 1 |
| Wac | Wallace, R. | Johannesburg | South Africa | 2 |
| Wrr | Warren, Wayne | Beltsville | Maryland - USA | 1 |
| Wei | Weier, David | Brooklyn | Wisconsin - USA | 3 |
| Wet | Wetmore, John | Bethesda | Maryland - USA | 1 |
| Zwk | Zawilski, Marek | Lodz | Poland | 1 |

NOTES:

1. Mar 11 Gyptis. See [O.N. 5(4), p.93]. Observers were BffBrtCasCvgDbnDssGdiGenGlzGrcHerHffIelKhlOtdSnzSza.
2. Mar 13 Semiramis. Observers were DssMddBulWetTruDwdWrr.
3. Mar 13 Diana. After the original prediction was distributed, it was found that the star was double, with both components having magnitude 9.8 in PA of 170°. David Dunham computed an updated prediction for both components, showing A across Australia and B across New Zealand. Rob McNaught obtained two updates at Siding Spring Observatory, showing a mean path 0.6 arcsec south of Dunham's. Negative observations were made by BlkTreStoGriRolGemNesKruPajMot.
4. Mar 13 Beatrix. See [O.N. 5(4), p.93]. Observers were BffBkwDlrDssDtyEllIdbJcrPtkScrSykSzaTbzTvhZwk.
5. Mar 18 Laetitia. Observers were BdwBulDssEllFrdGrcIelJstKhlKocMlnMosNelPohSkkSykSzkTbz.
6. May 10 Minerva. Bob Hindsley at Black Birch Observatory obtained an update plate showing a 0.6 arcsec shift north across Canberra and Dunedin. No events were seen.



## SOLAR SYSTEM OCCULTATIONS DURING 1992

David W. Dunham

This is a continuation of the article with the same title begun on p. 130 of the last issue. This issue contains regional maps, world charts by M. Sôma, and finder charts (for events potentially visible from North America and Europe for which finder charts were not produced by Edwin Goffin) generally for events that will occur during the 2nd quarter of 1992, and update notes, below:

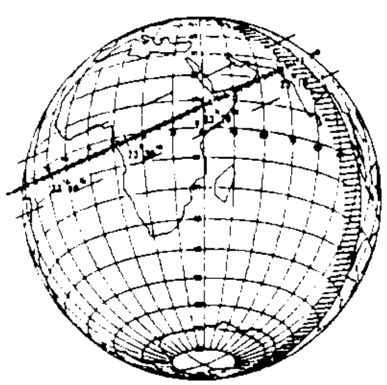
April 18: Karen Gloria took 3 exposures of 44 Nysa on April 9th at Van Vleck Observatory, and when combined with a position of the star measured by Arnold Klemola from a 1978 Lick Observatory plate, yielded a north shift that put the path across southern Oregon, Oklahoma, and northern Florida. I notified several observers, but have heard of no observations of the occultation. Unfortunately, bad weather in Connecticut prevented updates for three better occultations earlier in April; on the 9th (UT), it was clear for only a few hours in the evening, when only Nysa was in position for photographing. More observatories in other places, especially where the weather is better than in southern New England, need to participate in this astrometric program in order to obtain updates for a reasonable fraction of the priority events listed on p. 142 of the last issue.

April 30: The star is 20 Piscium = Z.C. 3505.

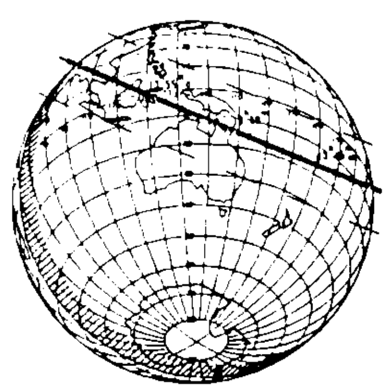
May 2, Hermione: Klemola's measurement of an old Lick plate showed that the star was over 1" south of its A.C. position, indicating that the path would miss the Earth's surface to the north with either Goffin's or my ephemeris for Hermione.

May 21: A comprehensive article about the occultation of P 17 by Pluto starts on p. 545 of the May issue of Sky and Telescope. It includes a finder chart and portion of a Palomar Sky Survey plate that will help you locate the star better than any charts that I could prepare. The nominally-predicted wedge-shaped area of visibility including the northern U.S.A. and southern Canada is shown on the Western Hemisphere regional map. Unfortunately, Larry Wasserman's calculations at Lowell Observatory, based on plates taken by Arnold Klemola at Lick Observatory on March 28th, indicate that the occultation path will miss the Earth's surface to the north. This is confirmed by calculations of measurements of CCD strip scans obtained at Wallace Observatory, and by observations made with the Carlsberg meridian circle on La Palma (IAU Circular 5500, April 20).

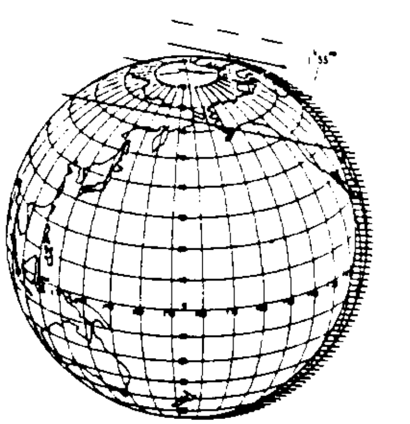
June 26: The star is Mu Cancri = ZC 1224. Contact Hans Bode (see IOTA NEWS - Astrometry meeting) for possible efforts to observe this rare occultation of a bright star by Mercury.



SAO 187936 by Lutetia 92 Jun 10

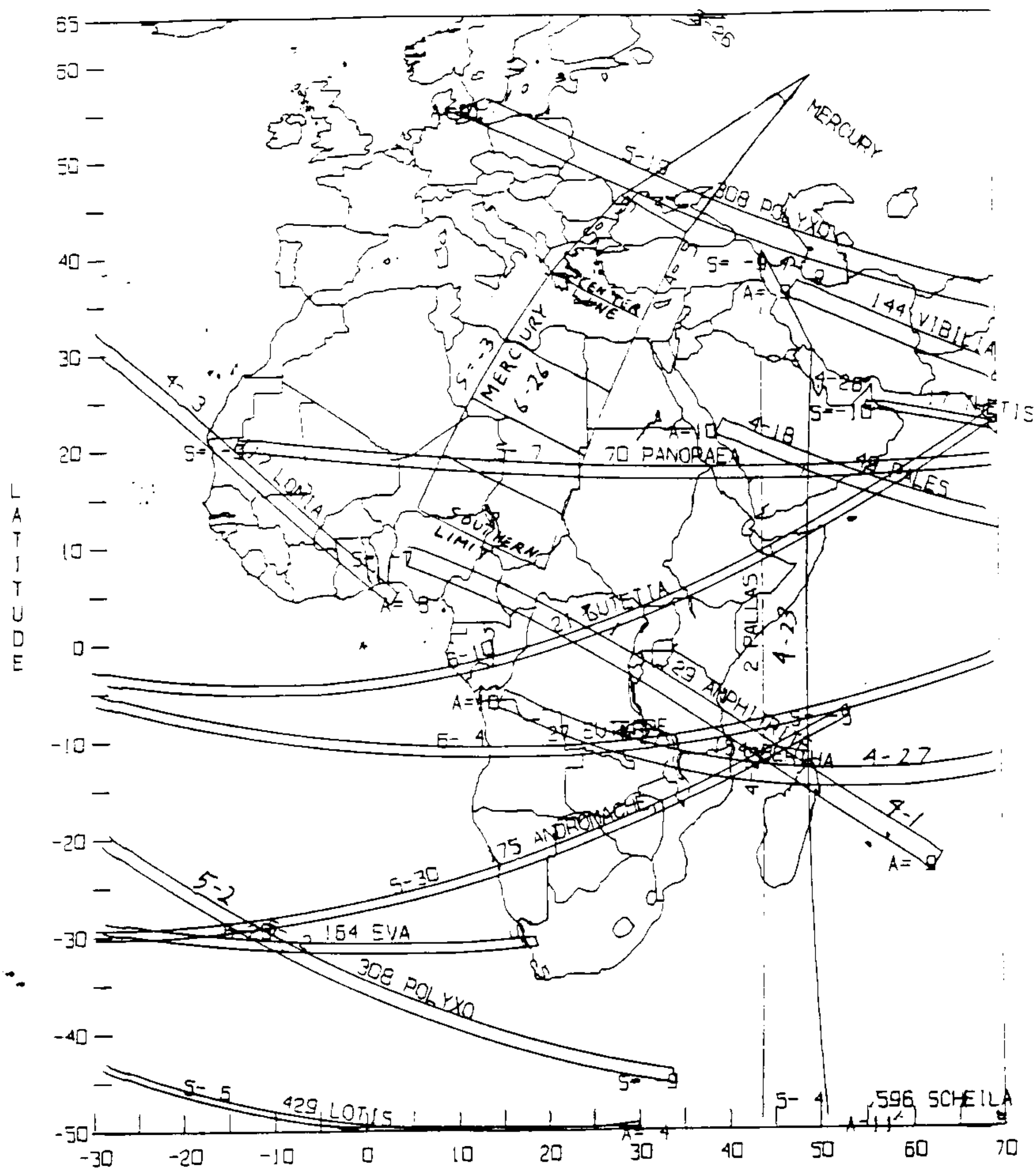


SAO 207622 by Argentina 92 Jun 15

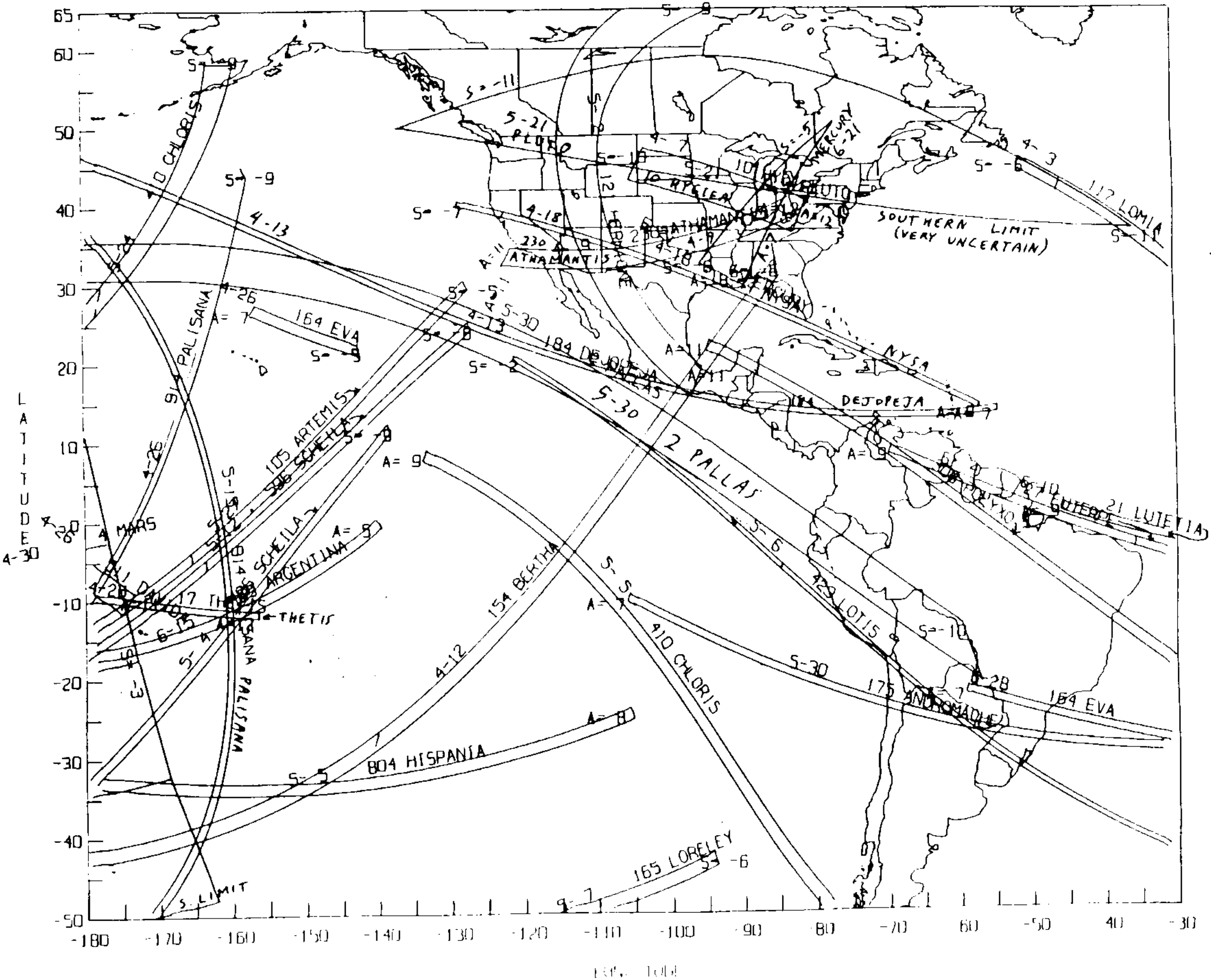


SAO 79471 by Mercury 92 Jun 21

PLANETARY OCCULTATIONS, 1992 APRIL-JUNE



PLANETARY OCCULTATIONS. 1992 APRIL-JUNE



## DONATING COMPUTER EQUIPMENT TO IOTA

Joan Bixby Dunham

Computing occultation predictions, supporting their distribution, preparing the newsletter, and managing the secretarial and treasury duties involves the use of lots of computers. While they are not particularly expensive, there are many IOTA members who cannot afford them, and are then limited in the help they can provide. If you or your company are upgrading your computers or printers, consider donating the old ones to IOTA.

If you have some equipment to donate, please contact me to discuss it. Remember that donated equipment becomes the property of IOTA, and the board reserves the right to determine how and where it is used (in other words, please do not ask us to accept a donation with conditions on where or how it is to be used.)

Donations to IOTA qualify as charitable donations for American taxpayers and corporations. Determining the value of computer equipment for the purpose of obtaining a deduction on the income tax can be difficult as computer equipment seems to change in value (usually down) from moment to moment. You or your company will have to determine the value, and answer any questions the IRS might have. However, IOTA will not sell the equipment, so you will not be embarrassed by seeing equipment sold for much less than the value you claimed for it.

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## ASTRONOMY AND PERSONAL COMPUTERS

Joan Bixby Dunham

Astronomical Computing: Jean Meeus has written a new book on computing in astronomy, called Astronomical Algorithms. This is a very useful book and I recommend it highly. It is a considerable expansion over his previous book on the same subject, Astronomical Formulae for Calculators. The publisher is Willmann Bell, who sells by mail, and it is also sold through Sky Publishing Corporation. I also recommend that anyone who wants to try some of the more difficult and lengthy computations of Meeus' book, such as the planetary motions computations, purchase one of the companion diskettes that includes the software. Entering the pages and pages of numbers for some of the series could be tedious; the diskettes are well worth the extra expense.

Interpolation and Extrapolation: Interpolation and extrapolation are techniques of obtaining from a table of values of a function at a set of times, values at other times. When interpolating, the tabulated values are given at times both larger and smaller than the desired time. Extrapolating is going beyond the tabulated values, so all of their times are either larger or smaller than the time of interest. Extrapolating far from the end of the tabulated values can be risky.

Examples of when interpolation is used in astronomy would include interpolating positions of solar system objects at specific times from the tables in the Astronomical Almanac, or interpolating an asteroid position from an IAU card with a table of predicted positions. Examples of interpolation for different techniques are given in Appendix K of the Astronomical Almanac, and in Jean Meeus' book, Astronomical Algorithms. There are examples of interpolation and discussions of various methods in many numerical methods textbooks, such as Numerical Recipes, by Press, et. al. and (my favorite book title) Numerical Methods that Work, by Acton. The numerical methods texts, however, usually do not have examples specific to astronomy. Also, the Royal Greenwich Observatory published a pamphlet on Interpolation and Allied Tables, which discusses extrapolation as well, and a second on Subtabulation.

Interpolation and extrapolation methods are relatively easy to program, even on a programmable calculator. The main difficulty is in understanding the notation. Most techniques are based on differences, so there needs to be a way to indicate the values of the function at different times (and those times), the first differences (differences between adjacent functions in the table), the second differences (differences between adjacent first differences), and so on. This can quickly lead to an intimidating set of negative and positive subscripts, subscripts in halves, and superscripts to indicate which difference (1st, 2nd, 3rd).

The interpolation methods can fail. We need to be careful when interpolating right ascension and declination near stationary points in an astroid orbit. If the tabulation interval includes the stationary point and it is moving quickly, the fourth and higher differences may be very large around the stationary point. In that region, some interpolation schemes may have difficulty generating a reasonable answer.

Also, if interpolating over angular measures (such as right ascension and declination), the angles cannot be interpolated when expressed in hours/minutes/seconds or degrees/minutes/seconds unless the object is very slow moving, so that only the seconds change. They will need to be changed to degrees and decimals of a degree (or hours and decimals of an hour), or to seconds, with care taken to handle cases where the angle rolls over 360° ($24^h$). When the angle changes from 360° to 0° (or vice versa), 360° should be added to the small angles or subtracted from the large ones, whichever is most convenient. The books by Meeus and by Press and co-authors include example programs if you want to try interpolation techniques but do not want to write your own programs. Also, interpolators can be easily programmed with a spreadsheet program.

## LUNAR OCCULTATION PREDICTION AND SOFTWARE NEWS

David W. Dunham

Occultation Visibility Subroutine (OCCVIS): Bradley Schaefer, at Goddard Space Flight Center, is well-known for his work on first visibility of the crescent moon, the green flash, the faintest star that can be seen with a given telescope, and similar problems. He has now applied his knowledge to the problem of visibility of stars during lunar occultations, and has written a program, called OCCVIS, that calculates, using astrophysical and physiological principles, the faintest magnitude star that can be seen under specified conditions with a specified telescope aperture. Working with extensive observations and comments supplied by Henk Bulder and Jean Bourgeois, Schaefer calibrated his equations with empirical data to help OCCVIS give realistic results. An article about this has been submitted to Sky and Telescope, and may appear in the July issue. I have run some tests with OCCVIS on the U. S. Naval Observatory's computer, and plan to incorporate it into the EVANS program for computing the detailed IOTA-USNO total lunar occultation predictions; a similar effort will be performed later for IOTA's graze program.

OCC Version 80L: For version 80L, photographic magnitudes of AGK3 non-SAO stars in the XZ and K catalogs were converted to "visual" magnitudes by subtracting B-V values calculated from the spectral type using SKYMAP values. Double star codes and data were updated with information published by Tony Murray up to and including his data in ON 5, #3, pp. 66-67. Also, only for the file used with USNO's OCC program, the R.A.'s of all of the XZ 80L stars were increased by $0^{s}020$ for better agreement with the current FK5 equinox and with the empirical corrections built into the OCC program, needed due to the current use of apparent-place solar and lunar ephemerides based on J2000 (DE200 and LE200 ephemerides, respectively), rather than the FK4-

B1950-based ephemerides used with OCC versions 80J and earlier. Otherwise, there is no difference between the positions and proper motions in XZ80J and XZ80L.

Variable star data were updated with data from David Herald's list of zodiacal variable stars distributed to IOTA members with a previous issue of ON. Although I was able to update the XZ variable star file, the Z.C. variable star file is limited to 50 entries, and my cursory examination of the convoluted OCC code revealed no easy way to change this. So I was able to include Z.C. variables only with magnitude ranges of 0.5 or more. Unfortunately, the OCC program is set up to use Z.C. variable data to override the XZ data for Z.C. stars, so the information for Z.C. stars with magnitude ranges of 0.5 or less is not given in the 1992 total and graze predictions. For grazes, the name is given, so if the star has an obvious variable star name, but no magnitude at minimum light is given, it can be assumed that the magnitude range is less than 0.5.

I had hoped to create an 80M version of the XZ for the 1993 predictions. The only change for 80M will be the updating of double star codes using data from Murray's ON lists that are not in the 80L version. Unfortunately, I probably will not have time to do it. In 1993, I hope to create a new J2000 version of the XZ, including ACRS and PPM data, and better magnitudes. Conversion of my planetary and asteroidal occultation software to J2000 will also have to wait until 1993, so my predictions for next year will be generated with my current B1950 software.

Netherlands Coordinator: The distributor of IOTA/USNO total occultation predictions for the Netherlands is:
Ton Schoenmaker; Mr. Homanstraat 8;
NL 9301 HP Roden; The Netherlands;
Telephone 05908-13382.
He was not at the ESOP X meeting last August, but Henk Bulder was, and collected the 1992 IOTA/USNO predictions for the Netherlands then. So Bulder was listed in ON Vol. 5, #5, p. 109 (November 1991).

Predictions for 1993: Verification forms for the 1993 IOTA/USNO total occultation predictions were due on April 30, but I have not received many of them, especially from European observers (some of them may have sent the forms to E. Bredner only; I will soon ask him which observers have responded to his mailings). In mid-May, I will send a 2nd-notice to those who have not responded; all forms need to be in by July 1, when I will update the files and start the 1993 production runs at USNO. I will not compute predictions for anyone who has not returned a form. After late September, USNO's computer will be turned off and predictions cannot be computed there after that. So those who return the forms late might not receive 1993 predictions.

Accomplishing all of the steps needed to generate the IOTA/USNO total occultation predictions for 1992 took more time than expected. I will start the process for 1993 only after this issue is distributed, later than I started last year. In addition, this year it is necessary to transfer all of the programs and datasets from the USNO computer to other machines, since USNO's computer, on which we have depended, will be shut down on October 1. With increased responsibilities at home and at work, we have less time and energy to devote to occultations than in previous years (one consequence is that this issue of ON is more than a month later than planned). Therefore, I must curtail some of my prediction work. The file of minor planet ephemerides for lunar occultations on the USNO computer ends in early January, 1993. Creating a new file to extend this coverage could jeopardize production of all of the 1993 predictions and the efforts to rehost the USNO software, so I will not do it. I may be able to generate the file in time for the 1994 predictions; but at least for 1993, the only predictions of lunar occultations of asteroids will be those provided by ILOC via the maps for the first four asteroids and planets published in the Japanese Ephemeris and reproduced in ON. Also, extended predictions of occultations of faint stars during this December's good total lunar eclipse can be provided only with help from others. Besides the 1993 predictions, I also hope to use the USNO computer to generate the input BEFILE's for 1994 (and maybe 1995) needed to generate the "ILOC/IOTA/USNO" total occultation predictions for those years, and the equivalent grazing occultation files for 1993-1995. Having these data files would give us more time to develop replacement software, if necessary. However, there is a good chance that these files will not all be generated before USNO's computer is turned off at the end of September; there may be difficulty just getting everything done for 1993. Answering requests for 1992 predictions will be delayed, especially when the observer already has predictions either with a higher O-code limit, or for a nearby site. If a new site is within 5 km of an existing station for which the observer has predictions, there is really no need for predictions for the new station, unless a lower O-code limit is needed. The station file will be updated to reflect changes of this nature before the 1993 prediction runs.

I will also need to decrease production of graze maps for 1993. I have informed Roy Bishop, editor of the RASC Observer's Handbook, that I will probably not be able to provide the same material for 1993 that I provided for the 1992 edition, and the hemispheric grazing occultation supplements for 1993 may be produced even later than they have been for 1992, if they are done at all.

Update of "USNO" Lunar Occultation Papers: Pat Trueblood made Marie Lukac's corrections to the USNO prediction documentation files, and typed "Precision Timing of Occultations". I have written modifications on listings of the files to make them up-to-date, but will not have time to type the corrections in the files, and print them to create new papers to distribute to IOTA/USNO prediction recipients, for several months, after other more urgent tasks are completed.

OCCRED to Replace Accurate Functions of OCC: Mitsuru Sôma has added geodetic datum corrections and other refinements to his OCCRED program so that it is now in agreement with USNO's OCC program to within 0".3 for over 95% of numerous test cases that I have provided him. His output files include virtually the same information for grazing occultation reduction/prediction that OCC produces, and he plans to create "lccard" output soon that provides the main link between IOTA's graze limit and profile (ACLPPP) programs. So the most accurate function of OCC may be the first to be replaced. For consistency, I will use OCC for 1992 graze predictions as long as possible. However, I definitely plan to use Sôma's OCCRED for the 1993 predictions.

Migration/Replacement of other USNO Occultation Software: Efforts at ILOC (using a mainframe computer) and by Claudio Costa in Italy (PC version) are progressing to rehost the EVANS program that is used to generate the IOTA/USNO total occultation predictions. Both hope to succeed within a few months, hopefully before USNO's computer is turned off. Wolfgang Zimmermann is working on software to generate the befiles (Besselian element files) needed by EVANS; he plans to use the latest J2000 ephemerides and standard apparent-place subroutines for this program. Eberhard Riedel's graze program already matches USNO's OCC program for selecting events, and his paths are in good agreement with IOTA's, as well. He plans to add graze datafile output, compatible with IOTA's graze program, so that IOTA's programs can still be used to generate detailed predictions and profiles for individual observers. CMS has been removed from the Goddard Space Flight Center IBM 3081 scientific computer, so conversion to the MVS operating system will be needed to run any predictions there.

Although I am having trouble with the predictions, noted above, progress by others to replace the USNO software functions is encouraging. With their success, it will be possible to distribute the prediction work, so that more comprehensive data can be provided in the future, with quicker responses from local and regional coordinators. Also, not so much of the burden of generating the predictions will be on me.

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## THE LUNAR OCCULTATION PACKAGE

A PC program by G. Taylor was mentioned on p. 145 of the last issue. The following is reprinted from the bulletin of the Lunar Section of the British Astronomical Society, Vol. 28, No. 2 (Mar. 1992):

Occultation Programs

The Lunar Section has been advised by Rob Harrold of the BAA Computing Section (Program and Data Library) that two versions of the Lunar Occultation Package written by G E Taylor are now available for sale. Details are as follows:

1st Version: Product Code P&DL0009
Title: One Disk Lunar Occultation Package
Price: 5 pounds 00 pence
Language: MS-DOS (IBM) QuickBasic V4.0
Size: 321,828 bytes in 17 files. Includes 4159 stars to mag. 8.0 in the Zodiac (within 6°61 of the ecliptic), and yearly lunar ephemerides from 1992 to 1999, inclusive.
Remarks: Runs from a single floppy disk, minimum 360K

2nd Version: Product Code P&DL0010
Title: The Lunar Occultation Package
Price: 10 pounds 00 pence
Language: MS-DOS (IBM) QuickBasic V4.0
Size: 723,968 bytes in 34 files. Includes 25138 stars in the Zodiac, and yearly lunar ephemerides 1992 to 2014, inclusive.
Remarks: Requires Hard Disk

Description: First published in 1991 by Gordon E. Taylor, current director of the Computing Section and formerly of the Royal Greenwich Observatory, England. These packages enable a potential user to quickly generate predictions of lunar occultations of stars for his own position, for one night at a time. Both packages contain subsets of the SAO star catalogue, epoch B1950.

For more information, write to: Rob Harrold, 10A Barker Avenue, RoseHeyworth Estate, Abertillery, Gwent, NP3 1SE, United Kingdom. [Ed. note: The XZ catalog has been sent to Taylor by IOTA/ES, so a version of LOP based on the XZ rather than the SAO should be available soon. IOTA is buying these packages and is trying to make arrangements for their distribution in North America. Taylor's program does not include limb corrections (addition of which would greatly increase the disk storage requirement with only a small gain in prediction accuracy) and many other features of the IOTA/USNO predictions, but it does the basic job. The program was written in 1991 partly in response to the possibility of no USNO predictions for 1992.]

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## SOLAR ECLIPSE NEWS

David W. Dunham

1992 January 4, annular: Paul Maley and Derald Nye tried to videorecord the eclipse at the northern limit from Ocha Island in the Truk Lagoon. Unfortunately, the sea was rough during the ride in a small boat to the island, and in spite of wrapping in plastic and canvas, both video systems suffered water damage so they did not work. The Sun was visible around annularity, so Derald and Denise Nye did obtain several good timed photos of Bailey's beads with a 1000-mm f/11 lens. Farther to the west, an IOTA/ES expedition led by Hans Bode managed to reach Arorae Island in the Gilbert Islands of Kiribati and in spite of some clouds, they were able to videorecord Bailey's bead events from their site a few km from the southern limit. A few days before Bode left for the eclipse, I got accurate geodetic positions for markers on Arorae, once classified information, but no longer.

David Werner, Joan, William, and I tried to observe the eclipse from the northern limit near Ventura, California, but although 2 hours before it looked like we had a reasonable chance, by eclipse time virtually the whole sky, especially the west towards the Sun, was covered with thick dark clouds. Areas near San Diego where the eclipse was seen did not have good enough visibility to distinguish limb events (in spite of some spectacular photos), and no bead timings were obtained there, as far as I know.

1992 June, total: Only the northern limit crosses any land (s.e. Uruguay just after sunrise), so no IOTA expedition is planned for this eclipse. Paul Maley is organizing a tourist expedition for this event, but due to the impossibility of obtaining Bailey's bead timings from accurately-known positions at both limits, it cannot be considered an IOTA effort.

1994 May, annular: The IOTA meeting for 1994 may be held with the Texas Star Party to try to observe this eclipse from western Texas and/or New Mexico.

1994 November 3, total: Tom Van Flandern is considering an Eclipse Edge expedition to Bolivia.

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## OCCULTATIONS IN THE LITERATURE

David W. Dunham

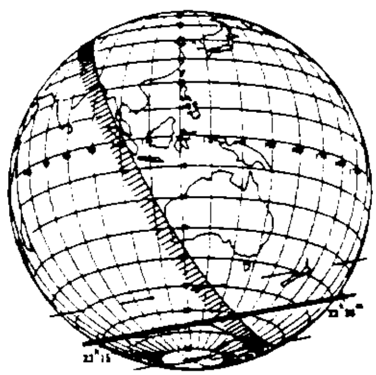
In the first few issues of ON, I listed current papers on occultations in the astronomical literature, and tried to give some brief description of them. Unfortunately, lack of time prevented me from continuing this effort. Starting with this issue, I will try to resume this effort, at least listing paper titles and authors, usually without any descriptions or comments. Prediction articles with only local interest will not be included. There are occultation subsections in Astronomy and Astrophysics Abstracts (AAA), but most ON subscribers do not have easy access to this, and AAA necessarily appears many months after the publications. If you know of any articles which I have missed (I am sure there are some, my search is far from thorough), please contact me at the Greenbelt address in the masthead, or telephone me at 1-301-4744722, or send me an E-mail message to:
nssdca::dunham (Decnet) or
dunham@nssdca.gsfc.nasa.gov (Internet).
Please include enough information to be able to make this listing.

"The Atmosphere of Neptune: An Analysis of Radio Occultation Data Acquired with Voyager 2", Gunnar F. Lindal, Astron. J. 103, 3, p. 967 (March 1992).

"Stellar Occultation Candidates from the Guide Star Catalog. I. Saturn, 1991-1999", A. S. Bosh and S. W. McDonald, Astron. J. 103, 3, p. 983 (March 1992).

"Analysis of Stellar Occultation Data for Planetary Atmospheres. I. Model Fitting, with Application to Pluto", J. L. Elliot and L. A. Young, Astron. J. 103, 3, p. 991 (March 1992).

"Magnitudes of Selected Stellar Occultation Candidates for Pluto and Other Planets, with New Predictions for Mars and Jupiter", C. B. Sybert et al., Astron. J. 103, 4, p. 1395 (April 1992).



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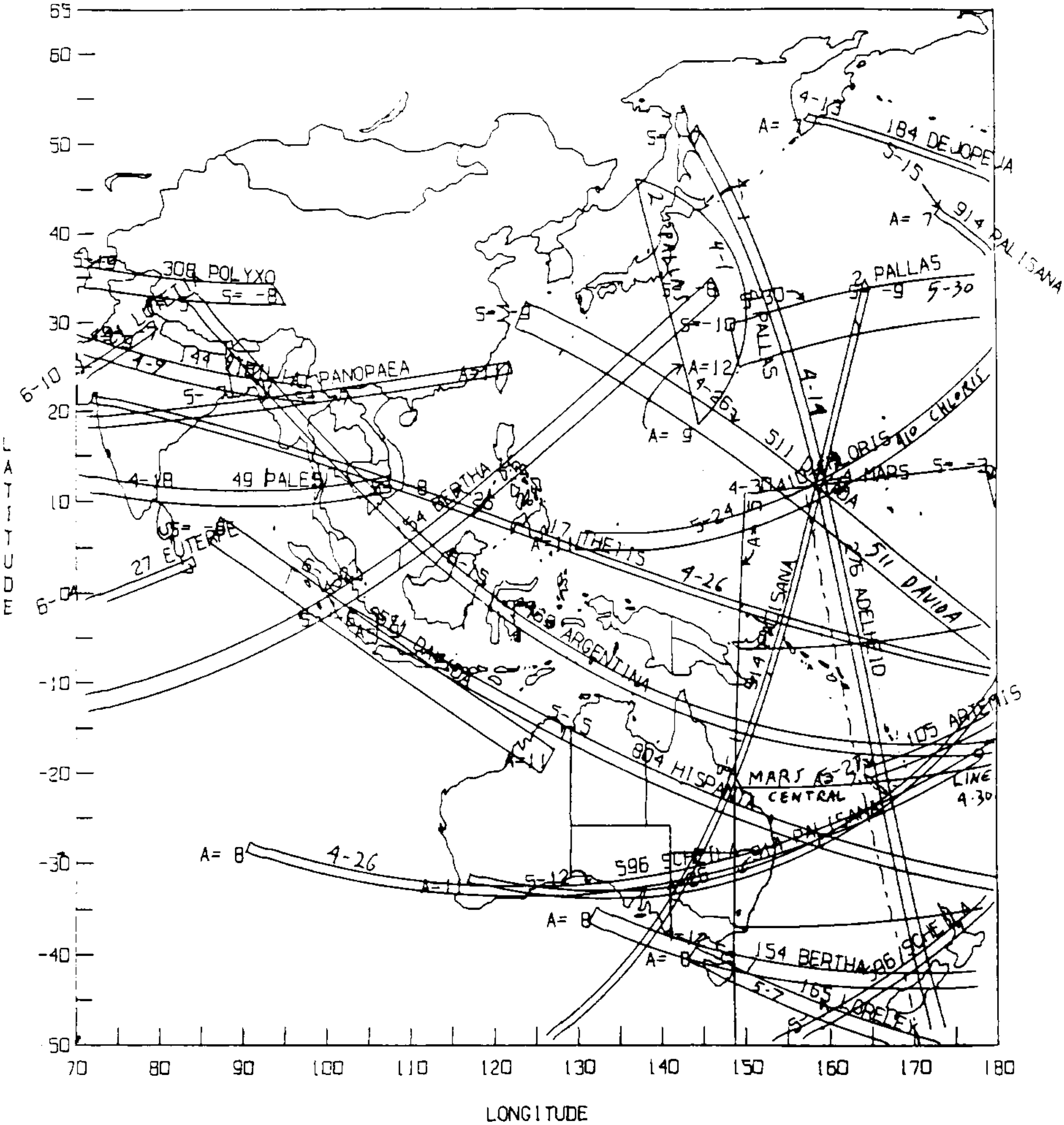
PLANETARY OCCULTATIONS. 1992 APRIL-JUNE



# DUST STORMS ON THE LUNAR TERMINATOR?

Richard P. Wilds and
Craig A. McManus

Many of us in IOTA can remember the excitement of the Apollo lunar landings. I remember how well people treated us on grazing occultations once they heard we were doing work on improving our knowledge of the Moon. With all the excitement, though, I cannot help wondering about some of the many observations made by the Apollo astronauts that are still waiting for explanations. One such example comes from the astronauts orbiting the Moon when they reported strange glows at various levels above the Moon as they came upon the lunar terminator (McCoy, 1976). Can anything be done to provide evidence in answering the cause of this phenomenon?

An interesting theory has been suggested in the Lunar Sourcebook, (1991) by W. David Carrier III, Lunar Geotechnical Institute; Gary Olhoeft, U.S. Geological Survey; and Wendell Mendell, NASA Johnson Space Center. Their article, "Physical Properties of the Lunar Surface" proposes lunar dust storms as an explanation of the astronauts' observations. Carrier, Olhoeft, and Mendell inform us that the lunar dust the astronauts kicked around becomes highly charged during the lunar night due to the lunar soil's poor electrical conductivity. The lunar soil is also highly responsive to solar irradiation. At sunrise on the terminator, the dust particles are supercharged by the sunlight. This appears to create a sizable electrical transfer between the two sides of the terminator (Alvarez, 1977). In their attempt to repel each other, the dust particles begin to levitate, thus raising a dust storm in the area of the terminator. This effect seems to occur at the sunset terminator as well (De & Criswell, 1977). According to experiments left by Apollo 17, dust storms may be on both sides of the terminator (Rhee, Berg, Wolf, 1977).

On January 14, 1992 I observed the graze of 6.5 mag. SAO 92801 (ZC 311), spectral class A3, near Chilocco, Oklahoma. The Cusp Angle was 3°7N, so I knew I would have to deal with being close to the terminator for some of my timings. My first 11 events were on the dark side and the 9.0 mag. secondary was involved in some of these timings. Event 11 was next to two sunlit peaks and was easy to see with no drop off in the star's intensity. However, just over a minute later, the star reappeared on the other side of the two peaks and was very difficult to see. This occurred between the sunlit peaks and the bright side. The star reappeared in an area that was still dark. Was the star difficult to see because it was near the bright side, or could its drop in brightness be due to a lunar dust storm between the star and myself?

I am suggesting a lunar dust storm hunt. Our team, HART, and other IOTA members have the ability to videorecord grazes. We will need to videorecord may events to prove or disprove the hypothesis of lunar dust storms. We often record grazes with large cusp angles to avoid the terminator and its problems. I suggest keeping in mind any bright grazes with small cusp angles. Record them with special attention to the star's spectral classification. Dust will affect a blue star more than a red star because blue light is blocked more by dust than light with longer wavelengths. Make special notation of the level of solar activity, since this will affect the strength of the supercharging event. Current levels, and predictions, of solar activity can be found on WWV during their Geophysical Alert broadcast at 18 minutes after each hour. If we get results that look promising, we will have the videos reduced by computer to produce a light curve of the star as it passes the terminator.

A complication for the theory in relation to grazes is that we are dealing with polar areas and their peculiar lighting characteristics. There will be areas of the polar regions that do not receive light from the Sun due to lunar libration, and no dust will appear in this region. However, at another libration the dust may be present. A possible advantage to working in the polar regions is that the lunar magnetic field, if one exists, could act as a mechanism for lifting the charged particles higher off the surface. Maria tend to have stronger magnetic fields than the highlands (Lin, Anderson, Bush, McGuire, & McCoy, 1976). These factors should add to the excitement of the hunt as well as to its difficulty. Let me know if you have any further ideas or suggestions concerning this matter. Please inform us of your results.

Richard Wilds is the Principal Investigator and Craig McManus the Technical Specialist for the Heartland Astronomical Research Team, which can be reached at

P.O. Box 3938
Topeka, KS 66604-6938

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Alvarez, R., Lunar Science VIII, The Lunar Science Institute. Houston, 1977.

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Rhee, J. W., Berg, O. E., & Wolf, H., COSPAR Space Research XVII, Pergamon. New York, 1977.

## IMPROVED WWV/WWVH VIDEO TIME TRIGGERING

Tom Campbell

I have designed the VCR Time Signal Amplifier and Clock Trigger (VTACT), a multipurpose device for assisting the video occultation observer. This is a sensitive microphone/pre-amplifier for the VCR audio soundtrack that responds to a very large dynamic range of input volume levels with automatic constant output volume. It is an audio filter for the speech or tone frequencies that enhances the audio time signal-to-noise ratio. It provides a constant volume low-level audio output signal (~40 dB) for Peter Manly's Model IV crystal clock/video time inserter's internal audio trigger. The most important feature of the VTACT is that it generates its own clock trigger output pulses with minimal time jitter for synchronization of an external clock to a shortwave time signal's minute tone. It also can be used to stop a clock's time insertion display (time freeze) to a known time signal minute tone, a useful feature for calculating video tape playback error.

The VTACT can also be used without a time inserter, to provide a good audio sound track on video taped events.

I plan to provide the VTACT as a finished and tested unit, or as a kit. The retail cost for just the parts for a unit (from Radio Shack) is $175. I am purchasing the parts wholesale for about $60 per unit. I expect to be able to sell these units to IOTA members for less than the retail costs of the parts and still receive compensation for my time to assemble and test each unit.

Don Stockbauer has been using a prototype VTACT to put time information on his video tapes. He has been very pleased with the unit's ability to pull a weak time signal "out of the mud".

It will be several months before I can supply the VTACT. I want to build and test samples and finish the owner's manual before I offer the VTACT for sale.

# REDUCING GRAZE OBSERVATIONS WITH A PERSONAL COMPUTER

Roger Giller

Lunar graze observations are an area where a PC can assist greatly in reducing the raw data to a usable form. I have used a couple of commonly available programs to reduce the data from a southern limb graze of Atlas on Dec 19th, 1991.

The first part of the reduction is to convert each observer's position to a distance from the predicted limit. I use a millimeter scale to measure the distances on the map and then scale these from the profile. Any spreadsheet program will perform the arithmetic that can otherwise become quite repetitive when there is a large number of stations (12 in the case of Atlas) and lead to mistakes. A similar calculation is required to determine the accurate latitudes and longitudes for reporting the observations to ILOC, and here again the spreadsheet helps.

It is when we try to fit the observations to the predicted profile and calculate any path shift that the computer comes into its own. CAD drawing programs are an ideal tool to plot the times and other data. I used Autosketch only because it was available, but others such as EZ-Cad, Generic CAD, etc., would suit just as well. The beauty of these programs is that one can draw on several different "layers". A layer can be thought of as electronic tracing paper and can be made visible or not as required. The ability to set origins, change line types, measure coordinates, etc., makes graze plotting easy.

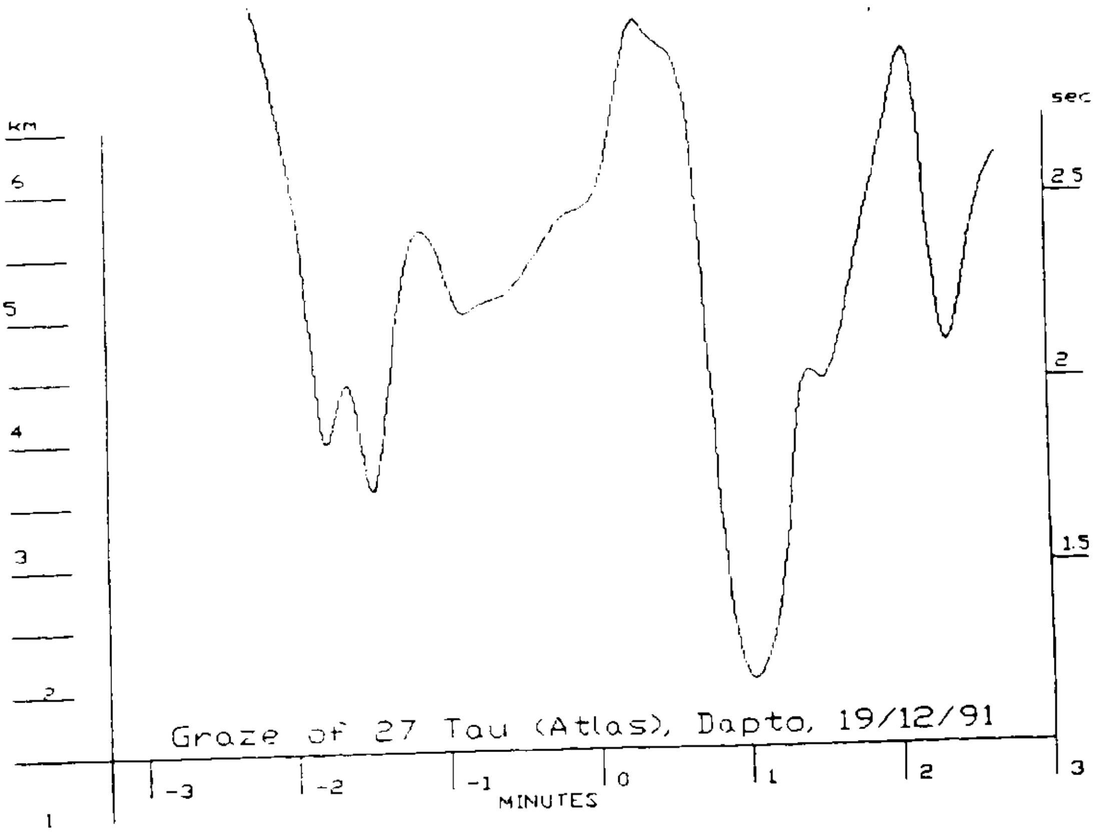
I divide the drawing into several layers. The first contains the vertical and horizontal axes. The latter is divided into minutes with 0 being the time of central graze. The vertical axis is scaled in kilometers or miles as required. Titles can also go on layer 1. On layer 2, I draw the predicted profile. This is done by measuring the curve at each * or number point. Measure in mm from each axis and use the spreadsheet to print a table of times from central graze and distance from the limit. Use the curve drawing function of the CAD program to plot them. It helps to use a different color for major parts of the plot.

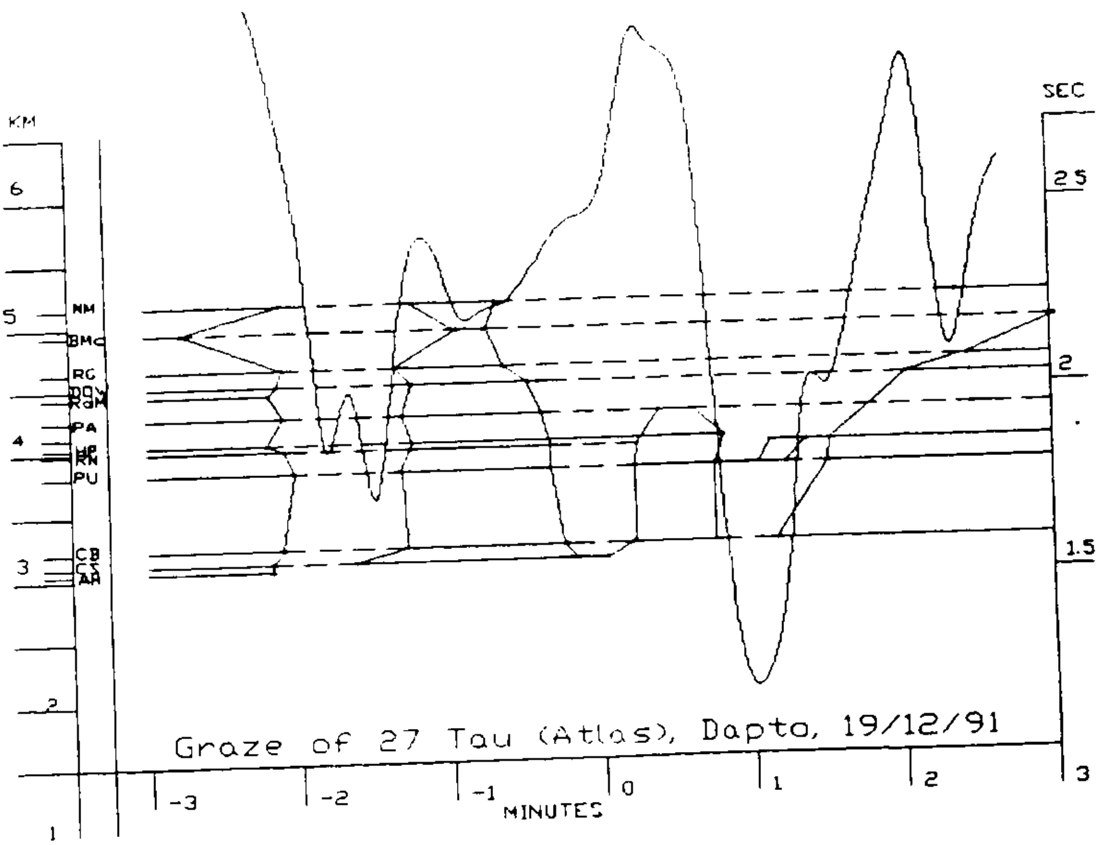
Small horizontal tick marks are placed on the vertical axis to mark each observer's distance from the limit, along with a site number or observer's initials. These go on layer 3.

On layer 4 I plot the observations, using a solid line for when the star is visible and a dashed line of a different color when it is hidden. The different color makes it easier to see on the screen and the line type difference allows for printing in black and white. I have found it easier to plot all of the observations as "points" first, using different colors for disappearance and reappearance. Then I join the points with the appropriate line type. I use the "ortho" function to keep the lines horizontal.

On the last layer, I join the groups of disappearances and reappearances to generate a profile. Once this is done, the predicted profile can be moved vertically until a best fit is achieved and any shift measured. The various layers of the drawing can then be printed, either singly or in any combination.

Ed Note: The examples Giller sent were four figures for a graze of Atlas observed in December, 1991, of which two are reproduced here. The first figure shows the predicted profile (layer 2) and the second combines the predicted and observed profile (all layers). It was not explained if the observations had been shifted vertically to make a better fit with the prediction. It is clear that the observers saw a valley where the prediction had a mountain.


KM
6
5
4
3
2
1
sec
2.5
2
1.5
3
Graze of 27 Tau (Atlas), Dapto, 19/12/91
-3
-2
-1
0
1
2
MINUTES


KM
6
5
4
3
2
1
NM
BMC
RG
PA
PU
CB
SEC
2.5
2
1.5
3
Graze of 27 Tau (Atlas), Dapto, 19/12/91
-3
-2
-1
0
1
2
MINUTES

## PAL VIDEO NEWS

**Henk Bulder**

We have a final count of 16 participants for the European group purchase of the CCIR version of the Philips 56470 module. Philips has notified me that delivery is delayed (probably end of April) due to the rescheduling of employees to new production lines. They officially stopped making the 56470 on January 1.

As a compensation for the delayed delivery, they will send me a sample of their new generation module. I will test this to see how its performance compares with the 56470 module. I will report on this in ON in due time.

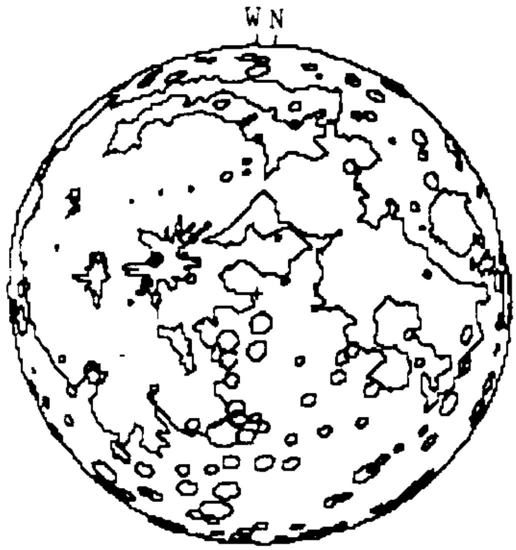
The final price for the "Cuno time inserter" is expected to be DFL = 80 (or around $45 USA), somewhat higher than we had expected. Pierre Vingerhoets will start manufacturing a series once some minor difficulties are overcome.

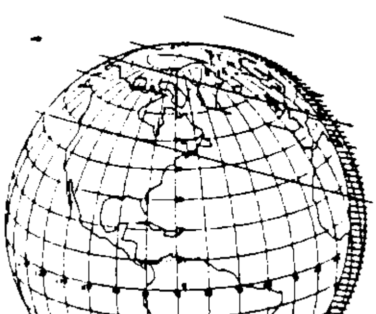
Prices for the DCF 77 receiver are BF 2500 (about $75 USA). There was considerable interest in this from all over Europe after it was published by EAON. Pierre Vingerhoets expects the final number of purchasers to exceed 100.

## THE PARTIAL ECLIPSE OF 1992 JUNE 15

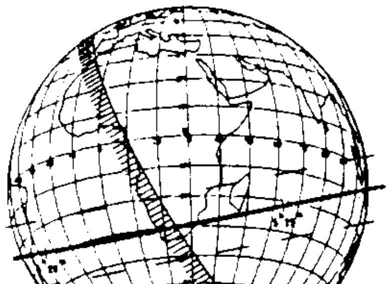
**David W. Dunham**

Occultations of 8th-magnitude stars visible from North America during this lunar eclipse are mentioned on p. 667 of the June issue of Sky and Telescope. A figure of the Moon with librations computed at the time of central eclipse for longitude 90° W., latitude 40° N., is shown below. N marks the direction of celestial north (from which position angles are measured) and W marks the direction of the Moon's axis (which, for practical purposes, is the direction from which Watts angles are measured). The view will be similar for the duration of the eclipse throughout its region of visibility. Bob Bolster created the figure with his version of John Westfall's MOONVIEW program.

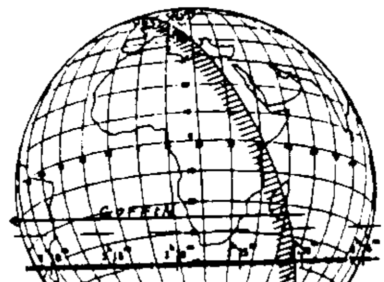


Mu Cancri by Mercury 92 Jun 26



SAO 148011 by Eva 92 Jun 28



SAO 165669 by Leto 92 Jul 4

## THE ZODIACAL SKY ATLAS 2000.0

**Blazej Feret**

The Zodiacal Sky Atlas is based on the SAO and the AGK3. The main part of the atlas is 27 maps of the zodiacal sky, 24 maps of the ecliptic and 3 additional maps for the Pleiades, the Hyades, and the Praesepe open clusters. The catalog part contains the coordinates and magnitudes from the source catalogs. The coordinates have been precessed to epoch 2000.0. The declination range of the charts is 25°, so they cover almost twice the area traversed by the Moon, to be useful also for most asteroidal events.

The star maps have all stars brighter than magnitude 8.5 from the SAO and the AGK3. The maps of the clusters contain all stars to magnitude 9.5. Messier Catalog objects brighter than magnitude 8.5 are also included on the main star maps. Constellation boundaries and stellar names have been plotted according to the Yale Bright Star Catalog and A. Becvar's Atlas Coeli, Skalnate Pleso.

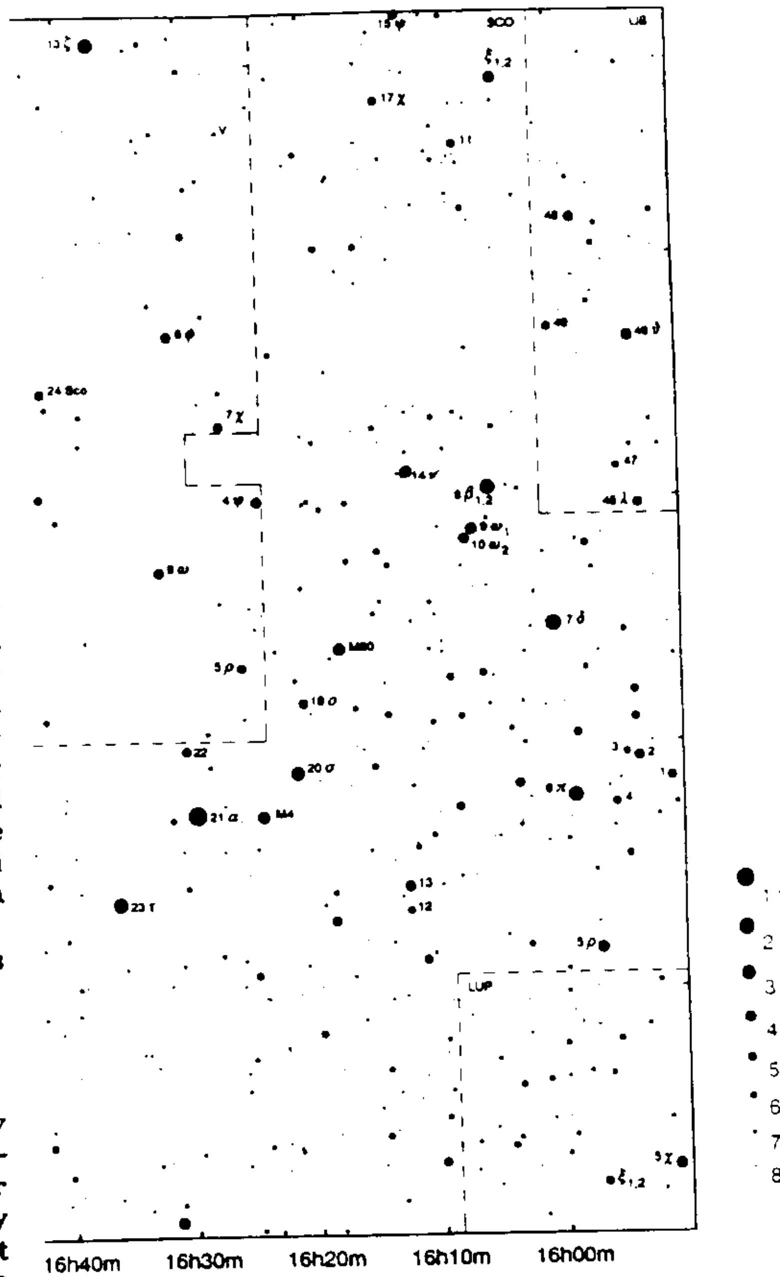
Preparing the atlas was possible through the kindness of the Astronomical Observatory and the Stellar Data Centre at Strasbourg, France, which has provided me with the magnetic tapes of the catalogs. The atlas star selection and plotting was done with software I wrote in Pascal and FORTRAN, using IBM/AT compatible microcomputers. The maps were printed using Xerox Ventura Publisher with a Hewlett Packard Laserjet III.

For more information on obtaining this atlas, write to me at:

PO Box 203
90-980 Lodz 7
Poland

Ed note: Mr. Feret has had difficulty finding a print shop capable of reproducing the Atlas without introducing "copier stars". He can provide a few copies by printing them separately, but cannot provide many. An example, part of a map from his atlas, is reproduced here. This map is reproduced at approximately the same scale as in the Atlas. This will almost certainly contain spots or specks that look like the points plotted for the stars, "copier stars".

**Map 17**



## LAST MINUTE ASTROMETRY NETWORK

Mike Kretlow and Dr. Dieter Boehme

It is not possible to make accurate predictions of occultations of stars by minor planets far in advance of the events. The predicted paths for the occultations can be in error by hundreds if not thousands of kilometers, due to errors in the star catalog positions and the ephemerides for the minor planets. Accurate predictions cannot be made until the two objects are close enough so that their separation can be observed astrometrically. In practical terms, this means that better predictions cannot be made until both the star and the asteroid can be photographed together. How far in advance of the event that is depends on the apparent motion of the asteroid and the field size of the plate.

Not very many people have astrographic instruments that photograph wide fields on plates, but many do have the capability to photograph onto small scale film, such as 35mm. Frequently, the star and asteroid will be close enough to fit on a 35mm negative about 3 days before the event. Experience has shown that corrected predictions based on last minute astrometry often result in successfully observed occultations. We want to organize a European Last Minute Astrometry Network (LMAN) of contributing astrometers to increase the number of successful asteroid occultation observations.

If you are interested, please contact either one of us at the addresses below for a list of the guidelines for the astrometers. We want observers able to make accurate astrometric observations of minor planets and stars down to photographic magnitudes of 14-15 and 12, respectively. The observer must be able to do a complete astrometric reduction. M. Kretlow can provide a FORTRAN 77 program for the data reduction, if needed. The first step will be to check the optics and measurement quality by reductions of Pleiades photographs. We want each of the contributing astrometers to send us a picture of the Pleiades centered on Alcyone exposed to the plate limit (to magnitude 14 or 15, if possible). We will measure and reduce the negative and provide the results.

Some of these ideas were discussed in February at a small meeting in Wiesbaden attended by Hans and Heliga Bode, Wolfgang Beisker, David Dunham (who was enroute home from a business trip), and me. Another meeting will be held in Hannover on May 17, as described in IOTA NEWS of this issue.

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Dr. Dieter Boehme
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## NEW DOUBLE STARS

Tony Murray

Since the last article on new double stars appeared in ON 5 (5), we have received 30 reports from 7 observers in 3 countries. These observers include J. Bourgeois in Belgium, H. Bulder in The Netherlands, R. Wilds, C. McManus, B. Culbertson, H. Povenmire, and myself from the USA. The table that accompanies this article contains 31 new double stars that will be added to IOTA's double star catalog. We are still sorting out some of the more than 200 observations received in 1991. In some cases, insufficient data were provided. These will be included in future lists as the work is finished.

Dr. Wayne Warren, while at the National Space Science Data Center at the Goddard Space Flight Center, arranged for me to receive a copy of the Washington Double Star Catalog on magnetic tape. Having access to the WDS will result in significant improvement to IOTA's catalog. Previously, our catalog was limited to stars with SAO numbers because we had no verification sources for non-SAO stars. Now, we are expanding our catalog to include stars with D.M. numbers, and, later, stars from other catalogs. If you report a discovery with no SAO number, but with a D.M. number, please include any other name/numbers you know for the star, along with its magnitude and all other pertinent data. Often, the WDS could not include all of the necessary information.

By now, everyone should have read about Harold Povenmire's discovery that the 6.0-magnitude star Z.C. 2524 (151 G. Ophiuchi) is a double star. His discovery was published on p. 231 of the February 1992 Sky and Telescope and in ON 5, #5, p. 120 (November, 1991). Povenmire sent me the details of the discovery for inclusion in IOTA's catalog. It is quite a surprise when a star as bright as 6th magnitude is discovered to be a binary. How could it have escaped detection until now? It may be that the stars had been too close together to be separated, and orbital motion of the pair produced a separation that allowed Povenmire to observe the companion during the graze.

### NOTES

Other than the observers mentioned at the beginning, other observers who have new double stars listed in the table are David Evans, David Edwards, and Graham Blow, all observing from McDonald Observatory, Texas. The reports of their double stars were first published in their series of articles, "Photoelectric Observations of Lunar Occultations", in the Astronomical Journal, volumes XI to XVI.

McManus timed the occultation of SAO 163497 while on a graze expedition in Hepler, Kansas. The graze of SAO 118023 was observed at Netawaka, Kansas, by and expedition of seven. Of these, Wilds, Culbertson, and McManus saw 118023 disappear as a fade or step event. Wilds led four observers to Keene, Kansas for the graze of SAO 78118, where McManus reported a fade event.

The star SAO 79386 was incorrectly called a new double star in ON 5(5), page 117. Actually, Bourgeois' observation of April 1, 1982 confirms its previously known duplicity.

In addition, the following 12 stars were reported as double whose duplicity had previously been discovered:

075775 - Bulder, 91Jan24
076149 - This is the Pleiad Taygeta. Bulder, 89Jun30.
077592 - Bulder, 91Sep03
077819 - Bourgeois, 89Sep22
078079 - Bourgeois, observing a graze, 91May16
093002 - Bulder, 91Nov20. Code previously K, now X.
093046 - Bourgeois, 89 Jun29. Code previously K, now X.
128275 - Bourgeois, 91Dec14
146315 - Bulder, 91Jan19
164623 - Bulder, 91Nov14. Code previously K, now X.
DM +03 0205 - Bulder, 83Feb17
DM +24 0567 - Bourgeois, 89Dep19

TABLE

| SAO | M | N | Mag1 | Mag2 | Sep | PA | Mag3 | Sep3 | PA3 | Date | Disc | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 077441 | T | M | 8.6 | 10.4 | 2.4 | 102 | 10.4 | | 96 | 91Mch22 | Bulder | Fainter star of previously known double is itself double. |
| 077486 | T | X | 9.8 | 9.8 | | 54 | | | | 91Mch22 | Bulder | |
| 078118 | G | K | 9.0 | 9 0 | | 360 | | | | 91Sep03 | McManus | |
| 078851 | T | K | 9.7 | 9.7 | | 329 | | | | 91Sep04 | Bourgeois | Near graze.Video records fade lasting .44 second. |
| 078921 | T | X | 7.7 | 7.7 | | 230 | | | | 91Sep04 | Bourgeois | Video records fade lasting .12 second. |
| 078970 | T | M | 9.5 | 10.7 | .77 | 249 | 10.7 | | 268 | 88Dec24 | Bourgeois | Fainter star of previously known double is itself double. |
| 092697 | G | X | 9.1 | 9.1 | | 343 | | | | 91Feb19 | Bourgeois | |
| 099087 | T | X | 9.5 | 9.5 | | 259 | | | | 88Dec28 | Bourgeois | |
| 118023 | G | X | 7.1 | 7.1 | | 32 | | | | 91Jun17 | Wilds et al | |
| 128313 | T | X | 9.9 | 9.9 | | 55 | | | | 91Dec14 | Bourgeois | |
| 138811 | T | X | 8.6 | 8.6 | | 291 | | | | 88Dec31 | Bourgeois | |
| 145921 | T | X | 9.7 | 9.7 | | 97 | | | | 91Oct19 | Murray | |
| 146105 | T | X | 9.3 | 9.3 | | 123 | | | | 91Nov11 | Bourgeois | |
| 163472 | T | X | 8.0 | 8.0 | | | | | | 91Nov13 | McManus | |
| 163479 | G | K | 8.0 | 8.0 | | 149 | | | | 91Nov13 | Wilds and McManus | |
| 163737 | T | X | 10.0 | 10.0 | | 101 | | | | 91Dec10 | Bourgeois | |
| 164576 | T | X | 9.2 | 9.2 | | 40 | | | | 91Nov14 | Bulder | |

TABLE

| SAO | M | N | Mag1 | Mag2 | Sep | PA | Mag3 | Sep3 | PA3 | Date | Disc | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 185474 | G | X | 6.8 | 6.8 | | 173 | | | | 91Sep16 | Povenmire | |
| +01 0237 | P | X | 9.8 | 10.0 | .075 | 235.5 | | | | 81Dec07 | Blow et al | |
| +15 0564 | P | X | 10.1 | 10.3 | .48 | 101.4 | | | | 81Oct16 | Blow et al | |
| +16 0633 | P | X | 9.4 | 9.7 | .065 | 146.9 | | | | 80Mch22 | Evans and Edwards | |
| +18 0922 | P | X | 10.2 | 12.0 | .1 | 217.8 | | | | 78Apr13 | Evans and Edwards | |
| +18 0929 | P | K | 9.6 | 12.0 | .025 | 213.1 | | | | 78Apr13 | Evans and Edwards | |
| +17 1416 | P | X | 10.0 | 10.5 | | 257.0 | | | | 77Jul19 | Evans et al | |
| +21 1548 | T | K | 11.5 | 11.5 | | 177 | | | | 91May17 | Bulder | |
| +17 1640 | P | X | 9.5 | 11.2 | | 238 | | | | 75May16 | Evans et al | |
| +16 1879 | T | X | 10.2 | 10.2 | | 85 | | | | 90May01 | Bulder | |
| +20 1912 | T | X | 11.3 | 11.3 | | 148 | | | | 91Mch24 | Bulder | Reports that star is one magnitude brigther than predicted. |
| -12 4008 | P | X | 9.6 | 10.2 | | 137 | | | | 77Jul24 | Evans et al | |
| -18 4305 | P | X | 9.7 | 10.5 | | 257 | | | | 77Jul19 | Evans et al | |
| -20 5127 | P | X | 9.6 | 9.8 | .017 | 34.0 | | | | 75Oct11 | Evans et al | |

## MOON TO OCCULT MERCURY IN A DEMONSTRATION OF RELATIVITY

Francis G. Graham

The Moon will occult Mercury on June 1, 1992, an event that gives us the possibility of observing a demonstration of Einstein's theory of general relativity.

At sunrise in northern Europe, and sunset in western Alaska, Mercury will be slightly less than 1° from the Sun when it is occulted by the Moon. At that time, Mercury will be on the other side of the Sun from the Earth, near superior conjunction.

Einstein's theory of general relativity says that the gravitational field of the Sun warps space-time such that the light passing by it is deflected. The amount of deflection is (Ref 1):

$$\text{Def} = (R/r)$$

where R is the angular radius of the Sun and r is the angular distance of the object from the Sun's center as seen by the observer. The angle  is the deflection at the solar limb, or 1".75. For an object seen at a separation of 1° from the Sun, the deflection is 0".35. This is certainly a small angle to measure, but since the Moon moves at an average of 0".55/sec, this can be a time difference in the occultation time of 0$^s$.63. Mercury is to be closer than this, hence the observed time difference should be approximately 1$^s$. Stellar occultations can be timed to the nearest tenth of a second. If this occultation could be observed, it could provide another demonstration of relativity. The deflection of light at optical wavelengths has been observed before, from the measurements of stars near the Sun for deflection during total solar eclipses. Occultations of quasars and of spacecraft have given data in the radio wavelengths.

Is it possible to observe Mercury so close to the solar limb? Mercury can be seen in daylight under clear skies with a long-focus telescope. The difficulty is observing it so close to the Sun. R. Baum tells me that Mercury has been seen at 6° from the Sun. Lowell Observatory has published observations at 4° (Ref. 2). The record appears to be an observation at 1°.1 from the Sun by J. E. Bortle at W. R. Brooks Observatory (Ref 3). Thus it seems that the observation is possible.

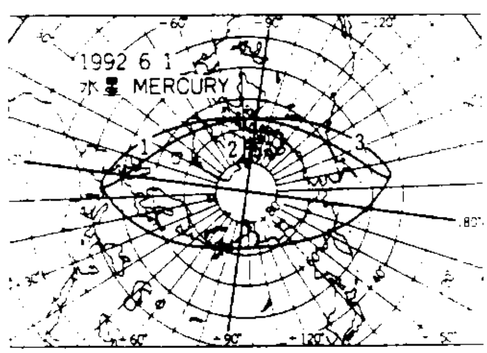
I attempted to observe such an occultation when Mercury was in superior conjunction and was occulted by the Moon in August, 1987. Unfortunately, bad weather at my location in Ohio destroyed my opportunity.

The best site for observing this event will be St. Petersburg (formerly Leningrad) in Russia. At the time of the occultation, the Moon will be at an altitude of 21° from the Pulkova Observatory. The disappearance is predicted for 04:07:44 UTC and the reappearance at 04:37:52. The times are for Mercury's center.

Visual observers will find the magnitude -2 Mercury nearly washed out in the Sun's glare. Accurate timing of the contacts will be very difficult. The limb of the Moon will not be visible. Also, the closeness of the Sun makes this observation dangerous. If even the slightest portion of the solar limb were to come into view in the telescope, it would ruin


References

1. Weinberg, S., Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity, Wiley, New York: 1972, pp 188-194.
2. Lowell, P. Memoirs Amer. Acd Arts & Sci., 12, 4 (1898).
3. Bortle, J. Sky and Telescope, 82 (1991) p. 580.

## IOTA FINANCIAL REPORT FOR 1991

Craig and Terri McManus

IOTA's income and expenses during 1991 are listed below:

**INCOME**

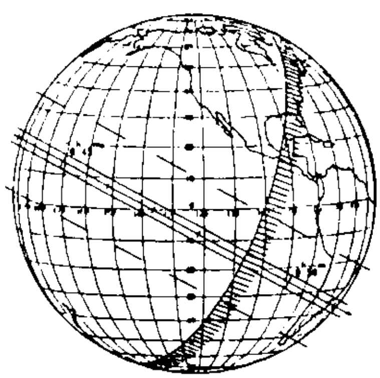
| | |
|---|---|
| Full Memberships | $6,485.47 |
| Gifts from Members | 102.50 |
| Interest on Checking | 116.34 |
| Non-member Predictions | 16.50 |
| O.N. Subscription Only | 872.64 |
| ON Back Issues | 8.50 |
| USNO Payment for Total Occs. | 1,000.00 |
| Preliminary Occultation Manual | 10.00 |
| Sale of IOTA Items | 9.18 |
| | ---------- |
| TOTAL INCOME | $8,621.13 |

**EXPENSES**

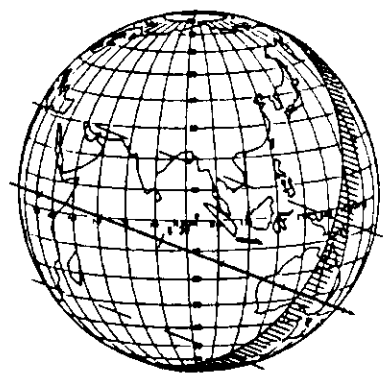
| | |
|---|---|
| Ast. & Graze Supplements | $348.62 |
| Credit Card Costs | 45.89 |
| Mailing Costs All | 2,730.91 |
| Newsletter Only | 3,300.05 |
| Office Expenses | 164.42 |
| other expenses | 25.00 |
| USNO Total Occ'n Mailing | 560.27 |
| | ---------- |
| TOTAL EXPENSES | $7,175.16 |
| | ---------- |
| TOTAL, INCOME-EXPENSES | $1,445.97 |
| | ========== |

A more detailed accounting by quarter is available upon request to us at 1177 Collins; Topeka, KS 66604-1524; U.S.A.

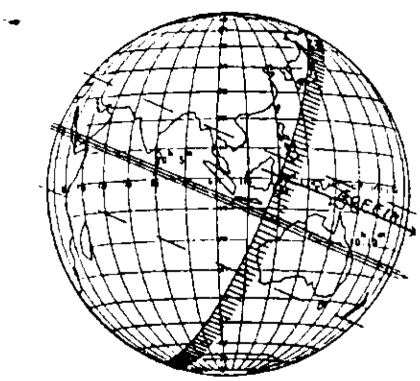
SAO 94081 by Meliboea 92 Jul 11



Anonymous by Vesta 92 Jul 18

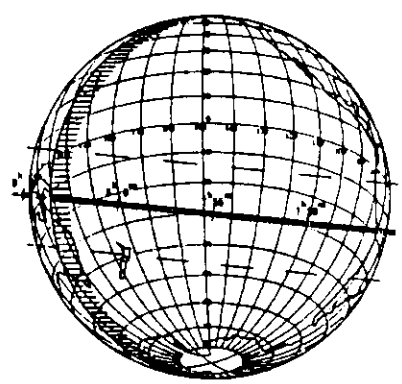


Rho Leonis by Grechko 92 Jul 18

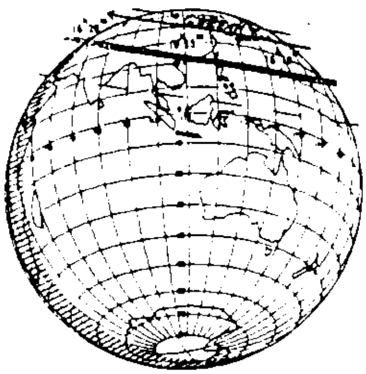


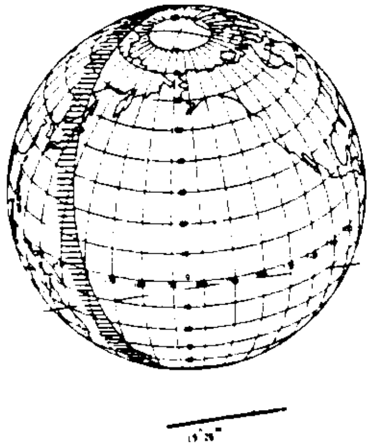
SAO 138959 by Themis 92 Jul 18

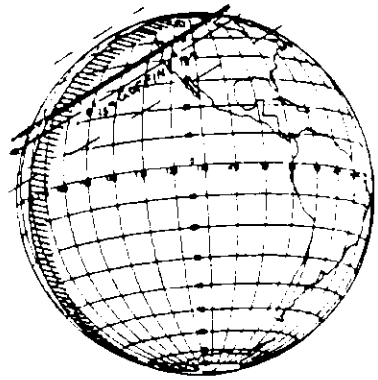
SAO 92440 by Notburga 92 Jul 19

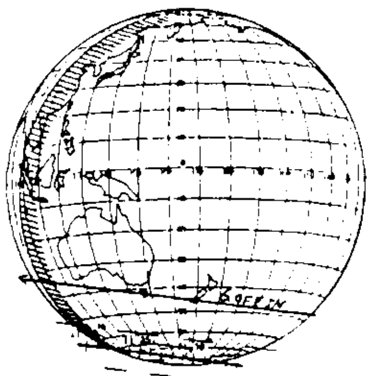


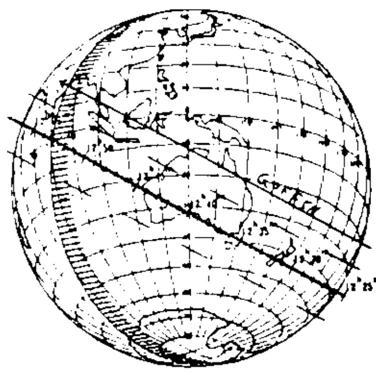
C24 13621 by Pales 92 Jul 19


SAO 188002 by Loreley 92 Jul 20

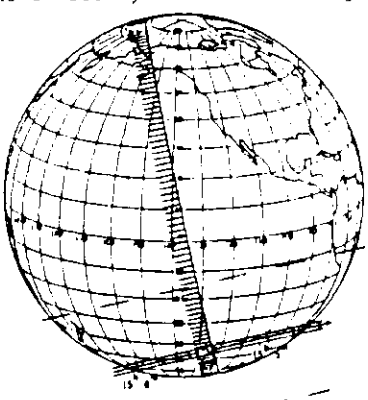

Anonymous by P/Sm-Wm-1 92 Aug 5

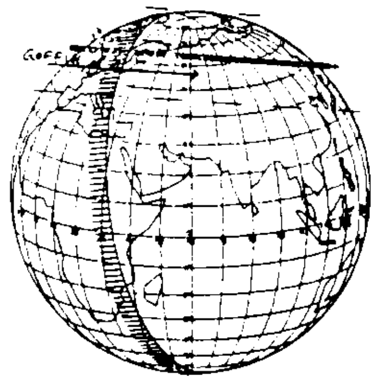

SAO 143850 by Veritas 92 Aug 9


SAO 144513 by Semiramis 92 Aug 20


SAO 188076 by Thyra 92 Aug 21


Anonymous by Melpomene 92 Aug 22


Anonymous by Sylvia 92 Aug 22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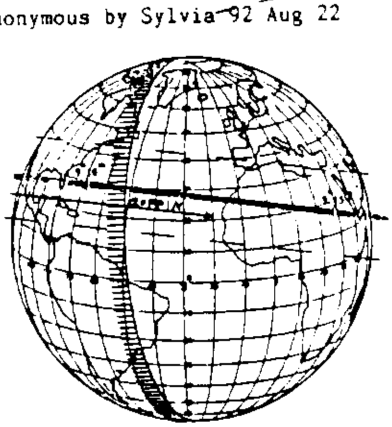
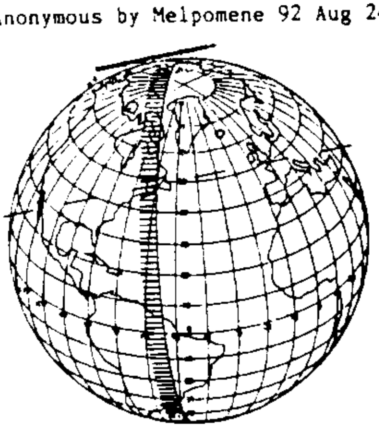
FAC 206502 by Melpomene 92 Sep 3


FAC 213405 by Melpomene 92 Sep 5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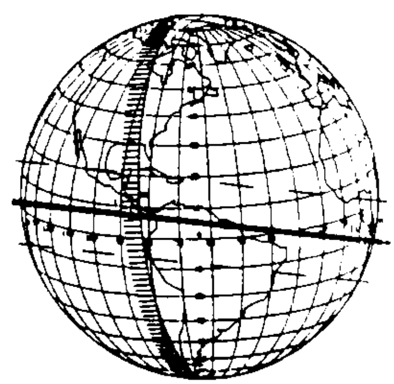
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## IOTA

The International Occultation Timing Association 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. IOTA is a tax-exempt organization under section 509(a)(2) of the (USA) Internal Revenue Code, and is incorporated in the state of Texas.

The ON is the IOTA newsletter and is published approximately four times a year. It is also available separately to non-members.

The officers of IOTA are:

| | |
|---|---|
| President | David W. Dunham |
| Executive Vice President | Paul Maley |
| Executive Secretary | Gary Nealis |
| Secretary-Treasurer | Craig and Terri McManus |
| VP for Grazing Occultation Services | Joe Senne |
| VP for Planetary Occ'n Services | Joseph Carroll |
| VP for Lunar Occultation Services | Walter Morgan |
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Addresses, membership and subscription rates, and information on where to write for predictions are found on the front page.

The Dunhams maintain the occultation information line at 301-474-4945. Messages may also be left at that number. When updates become available for asteroidal occultations in the central U.S.A., the information can also be obtained from either 708-259-2376 (Chicago) or 713-488-6871 (Houston); note that the area code given for the Chicago number on p. 77 of the January issue of Sky and Telescope is wrong.

Observers from Europe and the British isles should join IOTA/ES, sending DM 40.-- to the account IOTA/ES; Bartold-Knaust Strasse 8; 3000 Hannover 91; Postgiro Hannover 555 829 - 303; bank-code-number (Bankleitzahl) 250 100 30. Full membership in IOTA/ES includes the supplement for European observers (total and grazing occultations) and minor planet occultation data, including last-minute predictions, when available.

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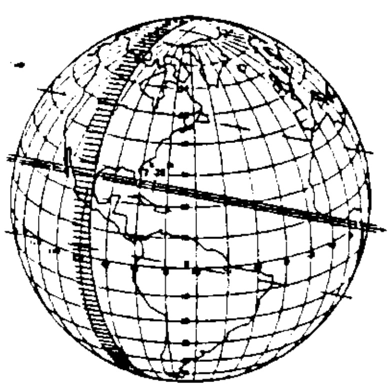

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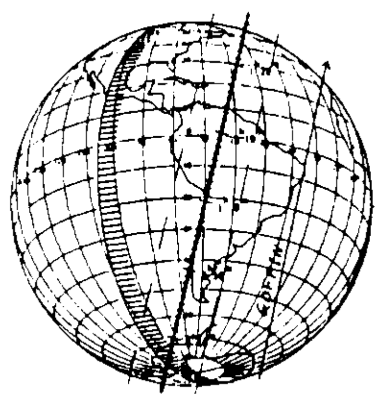

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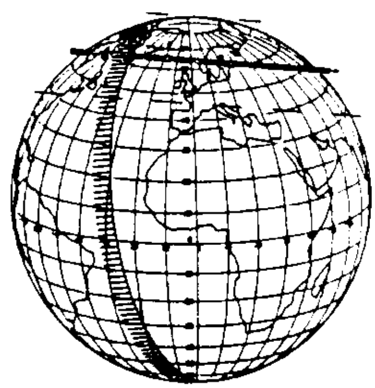

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