

# Occultation Newsletter

Volume V, Number 2

December 1990

ISBN 0737-6766

Occultation Newsletter is published by the International Occultation Timing Association. Editor and compositor: Joan Bixby Dunham; 7006 Megan Lane; Greenbelt, MD 20770-3012; U. S. A. Please send editorial matters to the above. Send new and renewal memberships and subscriptions, back issue requests, address changes, graze prediction requests, reimbursement requests, special requests, and other IOTA business, but not observation reports, to: Craig and Terri McManus; 1177 Collins; Topeka, KS 66604-1524; U.S.A.

## FROM THE PUBLISHER

For subscription purposes, this is the fourth issue of 1990. It is the second issue of Volume 5. Annual IOTA membership dues may be paid by check drawn on an American bank, money order, cash, or by charge to Visa or MasterCard. If you use Visa or MasterCard, include your account number, the expiration date, and your signature.

IOTA annual membership dues, including <u>ON</u> and supplements for U.S.A., Canada, and Mexico	\$25.00
for all others	30.00

<u>ON</u> subscription (1 year = 4 issues)	
for U.S.A., Canada, and Mexico (Note 1)	20.00
for all others	25.00

Single issues are 1/4 of the price shown.

Back issues of <u>ON</u>	
<u>ON</u> 1 (1) through <u>ON</u> 4 (1), each	2.50
<u>ON</u> 4 (2) through <u>ON</u> 4 (16), each	5.00

There are sixteen issues per volume, all still available. All overseas mailing is done via air (AO) mail.

Although they are available to IOTA members without charge, nonmembers must pay for these items:

Local circumstance (asteroidal appulse) predictions (entire current list for your location)	1.00
Graze limit and profile prediction (each graze)	1.50
Papers explaining the use of the predictions	2.50

Asteroidal occultation supplements will be available at extra cost: for South America through Ignacio Ferrin (Apartado 700; Merida 5101-A; Venezuela), for Europe through Roland Boninsegna (Rue de Mariembourg, 33; B-6381 DOORBES; Belgium) or IOTA/ES (see below), for southern Africa through M. O. Overbeek (Box 212; Edenvalle 1510; Republic of South Africa), for Australia and New Zealand through Graham Blow (P.O. Box 2241; Wellington, New Zealand), and for Japan through Toshio Hirose (1-13 Shimomaruko 1-chome; Ota-ku, Tokyo 146, Japan). Supplements for all other areas will be available from Jim Stamm (117891 V. 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; Postgira Hannover 555 829 - 303; bank-code-number (Bankleitzahl) 250 100 30.

## IOTA NEWS

David W. Dunham

The main purpose for this issue is to distribute information about planetary and asteroidal occultations during 1991, especially the important occultation by (4) Vesta the evening of July 3rd (see p. 28). Since this will be mailed a couple of days after Christmas, it should arrive in time for subscribers in the U.S.A., and most in Canada. Preprints of the Vesta/Kleopatra article were sent to subscribers in South America (and some in Canada) more than a week earlier, so hopefully they will receive that by January 3. Also included with this issue is the 1991 Grazing Occultation Supplement for your hemisphere. Significant changes had to be made for the 1991 grazing occultation predictions (see p. 33), which took time and delayed their distribution, but most observers should have received their 1st and 2nd quarter graze predictions before this arrives (unfortunately, predictions for the northeastern USA, southeastern Canada, India, and Latin America will be a little late). The data for total lunar occultations for W. Morgan in Calif., R. Harper in TX, K. Fabrin in Denmark, and H. Bode in Germany will be sent out only at the end of this month, so most will receive these late. Bode will not return from his trip to Australia and New Zealand for the January eclipse until the 19th of that month, so Europeans depending on him will receive those data quite late, but should be in time for the good European Pleiades passage on Feb. 21.

Help needed with July 1989 Saturn Data: Daniel Klos has written an easy-to-use PC-compatible program to help enter timings of the 1989 July 3 occultation of 28 Sagittarii by Saturn; see ON 4 (16), p. 382 and p. 1 of the last issue. The program generates files that he will send to Douglas Mink at the Center for Astrophysics in Cambridge, MA, to convert geographical coordinates and times to Saturn ring radii and longitudes. Since there are many reports with a total of many hundreds of timings, in different formats, Klos needs help in entering the data. If you have a PC or PC clone and can help, please contact Dan Klos; W404 County K; Brillion, WI 54110; U.S.A.; telephone 414,864-7948, and he will send you his data-entry program and some data to type. With help from just a few others, in addition to those who have already volunteered, the job will be manageable in a reasonable amount of time for everyone.

Klos also proposes transferring the program and data

by way of a bulletin board system (BBS) in Green Bay, WI. A friend of Klos' at a local college has set up an astronomy section on a large BBS. It can handle up to 9600 baud and can be reached at 414,337-9374 or 337-9460. The BBS can be (and has been) used also to exchange information and ideas about other occultations and other areas of astronomy.

I plan to publish maps in a future issue showing virtually all observers who submitted reports of the 1989 July 3 occultations of 28 Sgr by Saturn and by Titan. The map for the Titan event published several months ago needs to be updated; R. Boninsegni recently sent me a list of all of the observers who had sent him reports, and there were dozens of observers, especially in France and Spain, who were not included on my earlier map.

AD Reprints for the 1983 Pallas Occultation Paper: Reprints of the 1990 May Astronomical Journal article about the 1983 May 29 occultation of 1 Vulpeculae by (2) Pallas were distributed to regional coordinators in Arizona, Florida, and Texas (so they could distribute them to most of the observers) at the IOTA meeting in San Antonio last August. At the American Astronomical Society's Division for Planetary Science meeting in Charlottesville, VA, in late October, I distributed reprints to many of the non-IOTA coauthors. But there are still several coauthors who were neither at that meeting nor are in IOTA, and coordinators and some observers outside of AZ, FL, and TX who have not yet received reprints. Joan and I will mail them out early in January, after this issue and other prediction data are taken care of. We apologize for distributing them so late. After that, unfortunately, we will have only a few reprints left. Also, Joan is producing individual chord plots for each observer, to help each locate their chord; distribution of these will also probably be in January.

Antares Recording: Schmidtke's and Bessell's photo-electric recording of Antares' disappearance on 1990 August 1 is shown on p. 24 of the last issue. The important point is that there is clear evidence for a sodium shell surrounding the star and about ten times its continuum-light diameter. Possibly similar recordings can be made during the few remaining occultations of the current series, visible from the Northern Hemisphere early in 1991.

Next Issue: I have included an article about the 1991 March 20 Pleiades passage in this issue so that we will not need to produce another issue until April or even May. That should give us time to recover from the initial perturbations that will be caused by the addition to our family, due at the beginning of February. So far, there have been no significant problems with your editor's pregnancy. Unless you hear otherwise, contributions for the next issue should arrive here by April 15; receipt in ASCII files on MS-DOS compatible diskettes would be preferred, if that can be arranged, but don't hesitate to send typed pages, if not. Articles can also be sent to me by electronic mail; see the Coordination section of the Vesta/Kleopatra article on p. 28.

## GRAZE PATCHES STILL AVAILABLE

The graze patches that we produced earlier this year have proven to be very popular for those who have seen them. Plans for the patch and its design were published in ON 4 (14), p. 338 and 339; unfortunately, it is not possible to get a good reproduction of the multi-colored patch in ON. All profits from sales of the patches are being donated to IOTA. To obtain a patch, send a check or money order for \$5.00 payable to:

Phone:	Richard P. Wilds
(913) 271-7187	3630 S.W. Belle Ave, Topeka, KS 66614, USA.

## REPORTS OF ASTEROIDAL APPULSES AND OCCULTATIONS

Jim Stamin

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 the front page of the newsletter.

Reports received too late for inclusion in the previously published summaries:

(324) Bamberga and AGK3 -02° 0652, 1989 March 13; [ON 5, 1, p.9]: A miss from Greenbelt, Maryland observed by David and Joan Dunham; from the Goddard Observatory in Beltsville, Maryland by Jeff Guerber; and from Alexandria, Virginia by Robert Bolster.

(94) Aurora and SAO 208492, 1989 May 08: A miss from Phoenix, Arizona observed by Peter Manly.

(39) Laetitia and AGK +17° 1841, 1989 May 09; [ON 5, 1 p. 9]: A miss from Phoenix, Arizona observed by Peter Manly and Leroy Paller.

(481) Emita and SAO 119809, 1989 May 26; [ON 5, 1 p. 9]: Peter Manly recorded a miss from Phoenix, Arizona. Leroy Paller and Gerry Rattley, who were about 13 km north of Manly obtained a spectacular video recording of a 5.7 second occultation beginning at 05:36:11.1. About 40 km north of Paller's station, Mark Pritzl saw an occultation of around 12 seconds  $\pm 2$ , using only an unsynchronized watch, so neither beginning nor ending times were obtained. These observations indicate a south shift of approximately 0.1 arc second, and an occultation beginning 1.2 minutes after Dunham's nominal prediction. This would place the path south of Brooklyn, Wisconsin, where a 3.9 second event beginning about 4.6 minutes after Dunham's prediction was timed.

European observers were treated to two positive observations on the same day! Roland Boninsegni describes two events on 1989 October 23 in the following article.

## EUROPEAN SECTION ASTEROIDAL OCCULTATION RESULTS

Roland Boninsegna

(521) Brixia and SAO 147658, 1989 October 23: The asteroid (521) Brixia occulted the star SAO 147658 on 1989 October 23 along a path crossing southern Germany, northern Switzerland, northern France, south of England, and Newfoundland, Canada.

This occultation was predicted by E. Goffin (1988), D. W. Dunham (1989) and L. H. Wasserman (1987). The last minute prediction from Lick Observatory was especially good. My analysis confirms that done by Reinhold Buechner, described on p. 6-7 of the last issue of *ON*.

146 Lucina and FAC 212517 on 1989 October 23: Observations were reported from five stations. Video recordings of the occultation were made from Pic-du-Midi and Haute Provence Observatories. Observers in Chamonix and Graz saw a miss. The data from the observatories will be analyzed and reduced by the AVIA system (see J.-E. Arlot et al., *Celestial Mechanics* 45, 129, 1989).

An occultation of 26.6 duration was recorded at Pic-du-Midi beginning at 23<sup>h</sup> 56<sup>m</sup> 57.4<sup>s</sup>. Both the disappearance and reappearance were sharp (see Fig. 1). Taking into account Lucina's apparent velocity, the chord observed at Pic-du-Midi was 102.6 km.

Possible secondary events were reported by Pierre Terrier observing in Chamonix, a 12.1 second occultation at 23<sup>h</sup> 54<sup>m</sup> 19.9<sup>s</sup>, and two blinks, one at 54<sup>m</sup> 59.0<sup>s</sup> and the other at 54<sup>m</sup> 38.2<sup>s</sup>. No other observers reported similar events. Chamonix was outside the occultation path. The time and duration of the longest secondary event implies an object of at least 47km diameter 0.6" from Lucina, which seems unlikely.

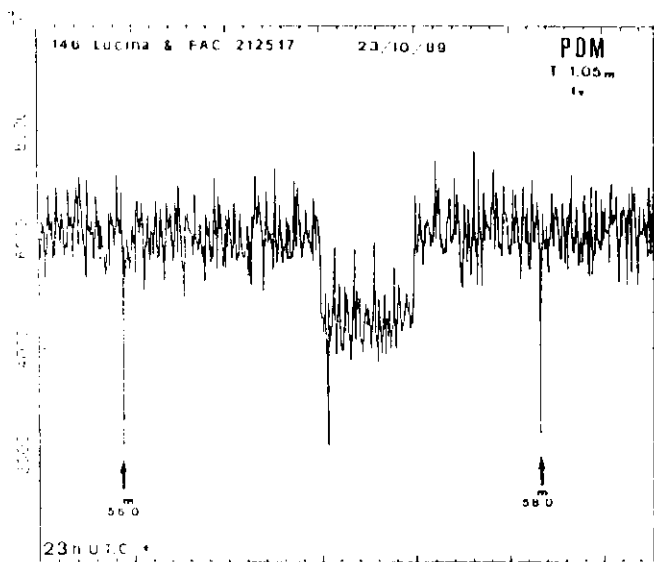


Fig. 1. Light curve of the occultation of FAC 212517 by 146 Lucina from the video recording made at Pic-du-Midi.

## POSSIBLE OCCULTATION BY COMET LEVY

Richard R. Didick

On the evening of 1990 September 3, at Norton, MA, I observed an occultation of 8.1-mag. SAO 186268 (= ADS 11049, which gives component mags. of 7.7 and 11.7, sep. 1".9 in P.A. 98°) by Comet Levy 1990c just east of M8. My notes:

50x) 0:56 UT, star begins to flicker irregularly.  
225x) 0:58 UT, star covered and gone from sight.  
225x) 1:00 UT, star reappears.

Unfortunately, I used a watch with no second hand. Barbara Lux (McKeesport, PA) and Gus Johnson (Swanton, MD) also observed the occultation.

[Ed. At the time, Comet Levy was quite bright, and the light of the inner coma probably simply overwhelmed the star; the telescope aperture and sky conditions were not reported. An actual occultation by the nucleus would have lasted at most a couple of seconds, and would have been visible from a path less than 50 km wide.]

## VIDEO NEWS

David W. Dunham

There have been no significant developments since those specified in my article on p. 12 of the last issue. However, in that issue, I did not mention the very compact equipment that Joan and I took to Alaska for last July's eclipse. We borrowed Wayne Warren's small Philips CCTV Corp. CCD-505 camera. For a video recorder and monitor, we bought a small Sony CCD-TR5 Handycam [ed - Now apparently replaced by models TR6 and TR7, TR5 may be available at a discount]. Although this has a non-removable lens, it does have video line input and audio input [for the latter, we borrowed Wayne's Omnitrac mixer described in *ON* 4 (16), p. 395, and have since purchased one] so that it can be used simply as a recorder - monitor. We have not performed exhaustive tests, but the Handycam's black-and-white monitor seems to show just about everything that can be seen with my 5-inch JVC monitor when used with black-and-white surveillance cameras. So the Handycam seems to have the necessary features of the GV-8 Video Walkman, for only a slightly greater cost, and in addition, you can take great day-to-day video with the camera. The Handycam retails for about \$1000 at Sony outlets, although batteries and other accessories that you will want to get with it will cost about \$200. Although this is not a cheap solution to the problem (less expensive alternatives have been described in previous VIDEO NEWS articles), the compactness, ease of use, and other capabilities of the Handycam make it attractive. Other small camcorders are available; we have not done an exhaustive comparison of their capabilities relative to the Handycam. Just after writing this article, I read an article about the Handycam by Elisabeth Bumiller, entitled "The Handycam Handymen - Behind This Season's Hot Gift, Sony's Incredible Shrinking Design Team", on p. C1 of the December 19, 1990 edition of *The Washington Post*.

Using my "old" system with image intensifier and 20-cm Schmidt-Cass telescope, I videorecorded 8 events during a graze of 8.8-mag. SAO 157572 from Columbia, MD on December 11; the Moon was a waning crescent, 27% sunlit, with central graze cusp angle  $16^\circ$ S and Moon altitude  $28^\circ$ .

---

PLANNING FOR THE JANUARY OCCULTATIONS  
BY VESTA AND KLEOPATRA

David W. Dunham

The occultations of SAO 93228 by (4) Vesta on 1991 January 3-4 and of SAO 115296 by (216) Kleopatra on January 19 are so favorable for North America that they were listed along with the 1990 planetary and asteroidal occultations in ON 4 (14), p. 348-349, last February. The Vesta occultation, involving a relatively bright star and a wide path (Vesta is the second largest asteroid), could even surpass the record 1983 May 29th occultation of 1 Vulpeculae by (2) Pallas. The Kleopatra event is important because it could confirm the contact binary (dumbbell shape) model inferred from radar observations of this asteroid. Hopefully, the major coverage of these events given in the January issues of Sky and Telescope (S&T, pp. 72 and 73) and Astronomy (pp. 54-57) magazines, as well as the extensive mailings by Harold Povenmire, will encourage hundreds of observers to attempt timings. The events can be observed by individuals or as a group project (with observers spread out, like a graze but on a larger scale), from fixed observatories or with portable equipment (see the coordination section below). General information on timing asteroidal occultations can be found on p. 288 of last September's issue of S&T, or in the Astronomy article mentioned above.

Since Vesta is the brightest asteroid, occultations by it of stars bright enough to detect visually are very rare. During the last 30 years or more that occultations by Vesta have been predicted, one of the few possible visual events was the one in northern South America on 1989 August 19, recorded photoelectrically from 3 stations set up in Ecuador by astronomers from Arizona. After January 3rd, there will not be another visually detectable occultation by Vesta until 1999, and the region of visibility of that event is Madagascar and part of the Indian Ocean.

When observers report timings, they should try to estimate their reaction times to events, and need to report these as well as give a statement saying clearly whether reaction times have been subtracted from the reported times or not. For Vesta, reaction times could be long due to the relatively small magnitude drop. For this situation, some recommend a smaller aperture, so the merged object goes closer to invisibility when the star disappears. But I believe a larger aperture helps, since there is a bigger change in the amount of light received by the eye when the event occurs. If the seeing is very bad, events may be hard to detect visually, and this will be made worse if the star turns out to be a close double, in which case there will be two less distinct magnitude drops. For the Vesta occultation,

do not tire yourself out staring at the combined image for a long time before the event hoping to catch a secondary occultation. If you do, take a break for 30 seconds or so 3 to 5 minutes before the main event, and then be especially attentive around the updated predicted time for your location. Because of the small velocity, we probably won't do as well for Vesta, but for the 1983 Pallas event, the last updated predicted time was within 8 seconds of the actual time (the path was very accurate, too). Of course, call out to your tape recorder any times that you are not watching the target star for any reason.

For Kleopatra, the predicted magnitude drop is 1.7, since the target star's visual mag. is 9.1, which seems to be confirmed by inspection of the True Visual Magnitude Atlas (TVMA). Hence, the larger magnitude drop given in the 1991 Asteroidal Occultation Supplement distributed with the last issue is very unlikely. Kleopatra has a rotational light curve that can exceed 1.0 magnitude. If it is near maximum light, its dumbbell shape will be presented broadside to us so that it can be revealed. But the magnitude drop will then be smaller, which may make an occultation a little difficult to detect visually if the seeing is bad. If near minimum light, the magnitude drop will be easy to see, but one of the ends will be presented toward us, making confirmation of the dumbbell shape difficult or impossible. This was the case for the rather well-observed 1980 October occultation by Kleopatra. It should be possible to predict the rotational phase for the time of the occultation from recent photometric observations, and this will be included on the update message lines noted below when it becomes available.

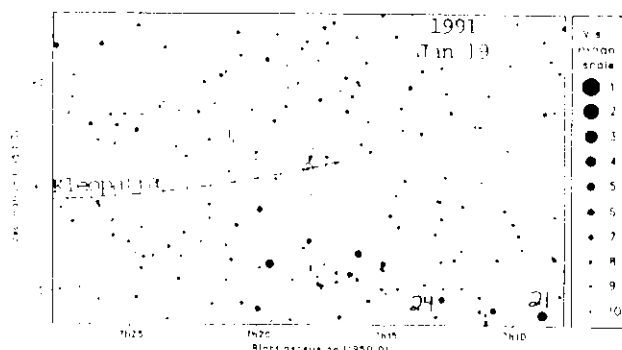
Observers can get some practice for the Vesta occultation by attempting the occultation of 80 Piscium by (205) Martha early the evening of Dec. 31 (see the 1990 Asteroidal Occultation Supplement distributed over a year ago, or p. 649 of the December issue of S&T). Practice at timing events, for inexperienced observers who may need it, can be obtained during the Pleiades passage the evening of December 28; consult your total lunar occultation predictions, the 1990 RASC Observer's Handbook, or p. 647 of the December issue of S&T.

Video: As noted in the S&T article, attempts to videorecord the occultation are strongly encouraged, since the star should be bright enough to detect with sensitive camcorders and moderate to large telescopes. Keeping the camera hand-held pointing into the eyepiece may work, especially if you can brace yourself against something such as a stepladder for stability. If the camera is mounted on a separate tripod, the tripod will have to be adjusted and moved to keep the camera pointed into the eyepiece during the 3 or more minute period that you will have to record to catch the main event. Whatever you do, experiment during a previous evening to be sure that you can record the target star for the necessary amount of time.

Finding the Target Stars: Detailed finder charts for these occultations by Edwin Goffin and David Werner are on pages 7 and 9 of the 1991 Asteroidal Occultation Supplement for North American Observers distrib-

uted with the last ON. Good charts are also given in the S&T and Astronomy articles, and can be referred to by observers who do not receive ON. These are quite adequate, although the Supplement charts show a few more of the fainter stars. Vesta will help identify SAO 93228, since the two will form an obvious bright close double "star" half an hour before the occultation. In any case, you should allow plenty of time to find the target star (half an hour may not be enough time), and practice doing it during a previous night. Knowing how to locate the star quickly could be important if on January 3rd, you are delayed for some reason in setting up (such as by clouds that move away from the target area only ten minutes before the event). If you have neither accurately-aligned setting circles nor computer-aided telescope pointing, and have to rely on star hopping, you should have at least an 8x50 finder scope. The finder scopes that come with most commercial telescopes are adequate for finding bright planets and the Moon (for lunar occultations), but most are very difficult to use for locating asteroidal occultation target stars. Straight-through finders are preferred since they give a direct view of the sky. If your finder has a diagonal (or "elbow"), it will give a reversed view. In this case, make a xerox copy of the finder chart and view it from the back by shining a flashlight through it. If the copy paper is thin, you may be able to make a reverse copy by turning your first copy upside down in the xerox machine and make a dark copy; then you could avoid the cumbersome procedure of shining a flashlight through the paper to see the reverse image.

Even the Supplement does not show some faint stars near SAO 115296 that might aid its identification, so I have used the TVMA to add them to the Supplement detailed chart, reproduced here. On the S&T chart for the Kleopatra event, a star just to the right of the "6" in "SAO 115296" is shown as brighter than SAO 115296, but it is actually 2 stars, each of which is about the same brightness as SAO 115296. The northern star of the pair is the brighter star. This pair is not shown on the Astronomy chart. The star shown just above (north of) the Kleopatra path arrow head on both of those magazine's charts, SAO 115274, is indicated as 0.4 mag. brighter than SAO 115296 in the SAO catalog, but in TVMA, it seems nearly a magnitude brighter; both stars have G5 spectra.

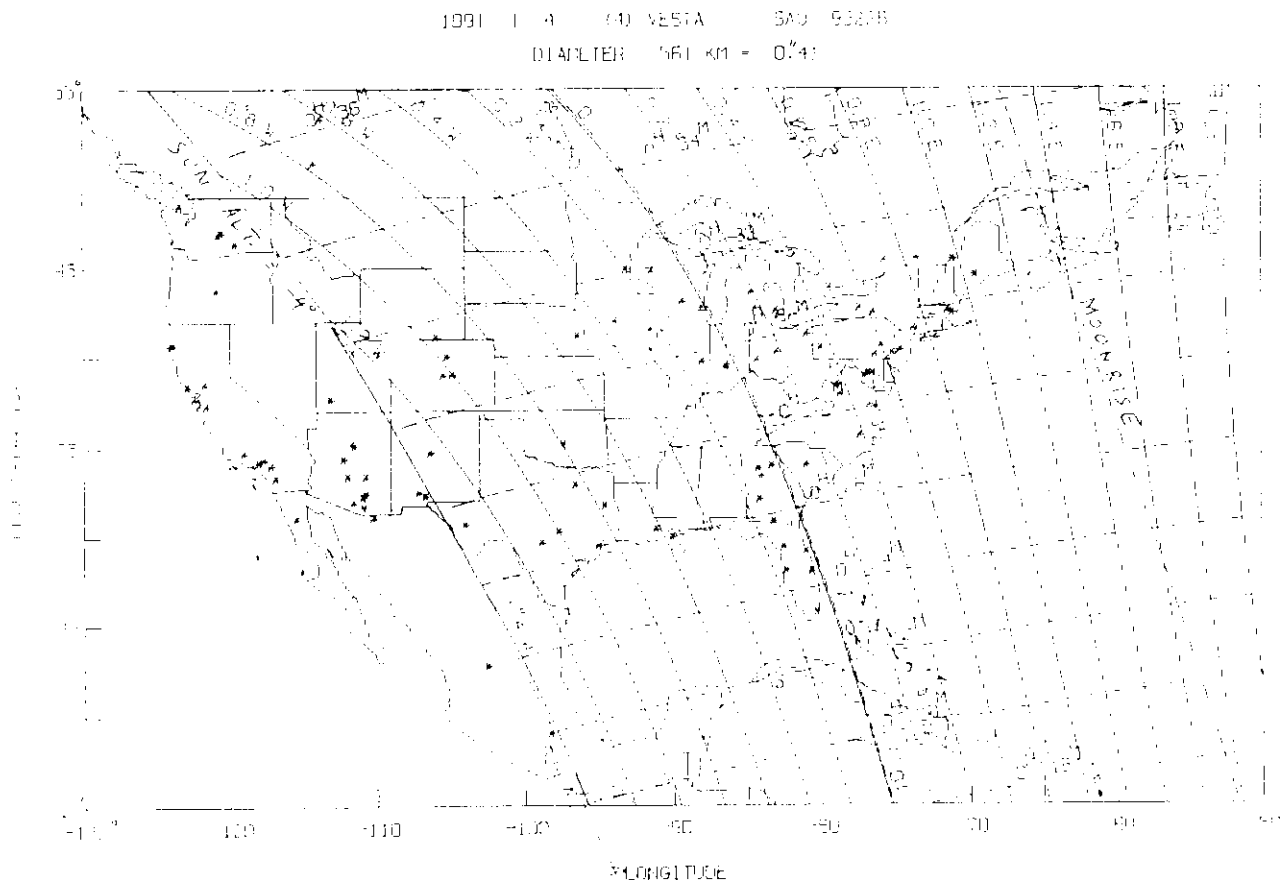


Regional Maps: Regional maps show possible parallel paths (isoskiatics) for the occultation in case of different specified shifts from the nominal prediction. They can be used to tell the nominal time and distance of closest approach at a given location, and to visualize path updates that will become available during the last several days before the occultation. When the first astrometric update becomes available, we will try to coordinate plans for the event, using a track system like that employed for the occultation of 14 Piscium by (51) Nemausa on 1983 September 11. If there is a large time correction, it will be necessary to generate a new nominal path. I will generate lists of isoskiatics at 0<sup>h</sup>01 or 0<sup>h</sup>02 intervals of shift values, and distribute these to regional coordinators. Tracks will be numbered at intervals of 0<sup>h</sup>001, so the isoskiatics that the regional coordinators will have will be separated by 10 or 20 tracks, sufficient for easy interpolation to determine the track number for any location near the expected occultation path. The exact definition of the tracks will need to wait until the first astrometric update, to give the best coverage for the area where the actual path is likely to be.

The predicted path for the Vesta occultation shown on the world maps by Goffin (in the Supplement) and by Soma are significantly east of my nominal path in North America. Soma used basic data provided by me, but since the Earth is shown only at the time of closest approach, and Vesta's motion is so slow, the Earth's rotation causes a significant error in his plot. Goffin tries to take this into account by interpolating between 5 accurately computed geographical points on his charts, but for Vesta, either this procedure was not entirely successful, or his ephemeris is different from mine. Vesta's orbit is perturbed slightly by Pallas, and I have not taken this into account, whereas Goffin has. In any case, asteroid paths near stationary points, as is the case for Vesta, generally have larger errors, so a recent astrometric update for the Vesta occultation is especially important. My current nominal path could be in error by 2 full path widths, maybe more. In terms of distance on the ground, the Kleopatra path should be more accurate, and all of the predictions are in quite good agreement.

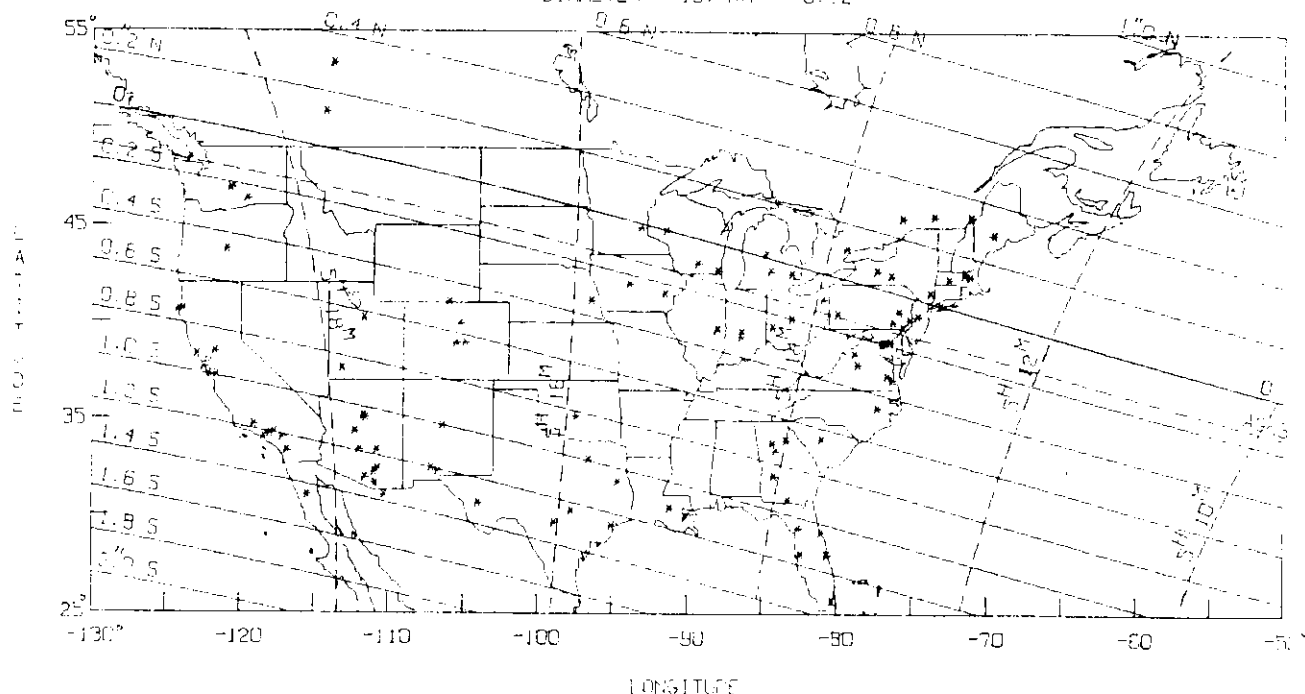
Coordination: Regional and local coordinators are sought to organize the overall effort. They will work with me to determine the track numbers (or the longitudes and latitudes so that I can determine the track numbers) of fixed-site observers and observatories in their region. Also, we need to identify those who are willing to travel to make observations with portable equipment, and about how far they are willing to travel; they will be especially important for filling in gaps in the coverage by fixed-site observers. It is not like a graze, where you have to be at a specific site along a road; the track assignments will be one or two miles wide, so that locations near motels, restaurants, or gas stations can be selected, where shelter from the cold, or perhaps AC power, will be available. I will combine the fixed-site data from all areas, determine which tracks need to be covered by the mobile observers, and inform the coordinators about which tracks should be covered by their mobile observers. The last step will probably not be done until Jan. 2, when good

be taken at Lick Observatory, may be available as early as December 21. For Kleopatra, the first update will probably come Jan. 10-12. Astrometric updates should be obtained from your local or regional coordinator, or they can be obtained by calling recorded messages at 301,474-4945 (main IOTA occultation update line, Greenbelt, MD), 312,259-2376 (Chicago), 713,488-6871 (Houston, don't use for Kleopatra), and 407,777-1303 (near Melbourne, FL, only for the Vesta event). It is important that mobile observers spread out to fill gaps in the overall coverage, especially near the edges of the updated path, which we hope to be able to predict reasonably accurately. Mobile observers should try to stick to track assignments given by their coordinator. Valuable data will be lost if all mobile observers head for the updated centerline. An asteroidal occultation, while certainly interesting to see, is not as spectacular as a solar eclipse or a passage of a crescent Moon across a star cluster. Although we will try to minimize them for mobile observers, miss observations are very important for defining the limiting edges of the asteroid, and for mapping the space around the asteroid for possible satellites or debris.



1991 1 19 12161 KLEOPATRA SAO 113296

DIAMETER 137 KM = 0".12



#### LAST-MINUTE ASTROMETRY AT VAN VLECK OBSERVATORY

David W. Dunham, Karen A. Gloria, Arthur R. Upgren,  
John T. Lee, and Arnold R. Klemola

We have updated predictions for several asteroidal occultations during 1990, using plates taken with a 24-inch telescope at Van Vleck Observatory at Wesleyan University in Middletown, Connecticut. David consults with Karen or Arthur to decide which events might be feasible, considering the telescope capabilities, everyone's schedule, etc., and sends ephemeris data and/or charts to Van Vleck, as needed. Karen exposes the plates, which cover a field about  $1^{\circ}2'$  wide and about  $0^{\circ}8'$  high. If the target object is visible after the plate has dried, it is taken to Yale University in New Haven, where John Lee uses the Astronomy Department's automated measuring engine to measure the plate. He then performs a plate reduction, usually using a secondary net of stars whose accurate positions have been determined by Arnold from a large plate taken at Lick Observatory sometime during the past 20 years. This generally results in rms residuals for the plate reduction of only a few hundredths of an arc second (often after discarding one or two stars whose unknown proper motions cause large residuals at current epochs). The final measurements of the star and/or asteroid are transmitted to David, who computes the updated prediction and notifies observers. In one case when Dunham was out of town, the updated prediction was calculated by Larry Wasserman at Lowell Observatory. The transmission of large amounts of computer-generated data by electronic mail between the authors has made the whole enterprise feasible. Unfortunately, so far, the updated paths have either missed astronomically populated parts of North America, or bad weather has

prevented observation in the region of the updated path. Some efforts made during late 1990, and their results, are listed below:

Sep. 2, (9) Metis and A24 51241, path over southern Oregon.

Sep. 16, (121) Hermione and A24 47735, path over northwestern Canada.

Sep. 30, (51) Nemausa and SAO 163983, north-south path in Pacific Ocean about 500 miles west of Calif.

Nov. 15, (704) Interamnia and anonymous A.C. star, path over southern Mexico.

Dec. 9, (704) Interamnia and anonymous A.C. star, combination of the ephemeris update from the plates taken before the Nov. 15 event and an updated star position from a Lick plate showed that the path would remain over northern Canada, so no further effort was made.

While others are concentrating on updating the upcoming Vesta and Kleopatra events, we are working to update the occultation of Alhena by Myrrha discussed on pages 7 and 8 of the last issue. Myrrha was photographed with a 20-minute exposure on December 15; measurement and reduction of the plate will be completed by about Dec. 27. Myrrha was at least as bright as mag. 13.0, at least half a mag. brighter than predicted. A rotating sector will be used to cut down Alhena's light so that its position can be determined accurately in the system of the same faint reference stars that will be used to update Myrrha's ephemeris during the few days before the occultation. After Myrrha, our next project may be to update the

occultation by (34) Circe on January 26.

The path of the November 17th occultation of an anonymous 11th-mag. A.C. star by (216) Kleopatra was updated with extensive astrometry taken at Lick and Lowell Observatories. The final prediction, decided upon only about 12 hours before the event, gave a path about two path widths southwest of my nominal path shown in *ON* 4 (16), p. 397 and in the Feb. 1990 issue of *S&T*. Unfortunately, overcast skies foiled attempts to record the occultation in Texas and New Mexico. Harold Reitsemá photoelectrically recorded a 10-second occultation at Dillon, Colorado.

## LUNAR OCCULTATIONS OF NEBULAE DURING 1991

David W. Dunham

During 1991, besides the Pleiades (which are tabulated in my Lunar Occultation Highlights article on p. 69 of the January 1991 issue of *Sky and Telescope*), the Moon will pass in front of several famous clusters in both the winter and summer Milky Way. These are listed in a table, where the nebula type, magnitude, diameter (size) in arc minutes, and approximate duration (dur.) in minutes for the Moon's edge to cover the nebula are given. These will be best seen with moderate to large telescopes. The occultations of M35 should be particularly impressive, with dozens of occultations of tenth-magnitude stars visible in less than two hours.

## THE 1991 MARCH 20-21 PLEIADES PASSAGE

David W. Dunham

From 23h to 1h U.T. of March 20-21 (Wednesday evening, March 20th, local time), the 25% sunlit Moon will pass over the southern and central part of the Pleiades shortly after sundown for observers in eastern North America. The passage will be more central for the southeastern U.S.A., but the passage will already be in progress at sundown there. The best views will be a little farther east where the passage will take place after dusk, in the Canadian Atlantic provinces (southern part of the cluster) or, best yet, from Bermuda, where the passage will be central. Much information about this passage, including predicted U.T.'s of disappearances of stars

down to mag. 8.5 and other data, will be included in

my article about the passage in the March issue of *Sky and Telescope*. This will be one of the best passages of the current series for eastern North America, and will be the last one involving nighttime occultations of the bright Pleiads visible from the U.S.A. or Canada until the next series starting in 2005.

**Pleiades Chart:** The chart of the Pleiades shows the topocentric paths of the Moon's center at night for St. John's, Newfoundland; Halifax, Nova Scotia; Bermuda; Washington, DC; Miami, FL; Kansas City, MO; and Mexico City. Data were also computed for Los Angeles, CA and Vancouver, B.C., but the paths for these cities are entirely before sunset across the chart. The city's name is plotted near the right-side (low right ascension) end of the path. Most paths start with a circled "S" marking sunset. Tick marks show the Moon's position at hourly intervals, with the U.T. hour of March 20 given above the tick mark (hence, "25" means 1h U.T. of March 21). The Moon moves from right to left (its R.A. is always increasing) across the chart.

The Moon's disk, produced with Bob Bolster's version of John Westfall's Moonview program, shows its correct size and orientation for the passage. Maria and craters are shown with solid lines on the sunlit part of the Moon on the right side. The advancing (left) side of the Moon will be illuminated faintly by Earthshine, so the maria and craters are shown with dotted lines.

USNO's special Pleiades P-catalog, based on H. Eichhorn's catalog of the cluster, was used for the stars. Known or suspected double stars are underlined. Information about binaries that will be occulted during this passage will be given in the March *S&T* article. Identifying numbers are just to the right of stars of mag. 11.0 and brighter. The chart uses apparent positions (equinox of date) so they can be located with the apparent positions given in the USNO total occultation predictions. SAO numbers will be indicated on the chart in *S&T*. The number key for the stars on the chart here is as follows:

- 7 - 520: USNO P-catalog number
- 530 - 570: Zodiacal Catalog (ZC) number
- 4750 - 5020: USNO XZ number, star not in P-catalog

## OCCULTATIONS OF NEBULAE DURING 1991, EXCLUDING THE PLEIADES

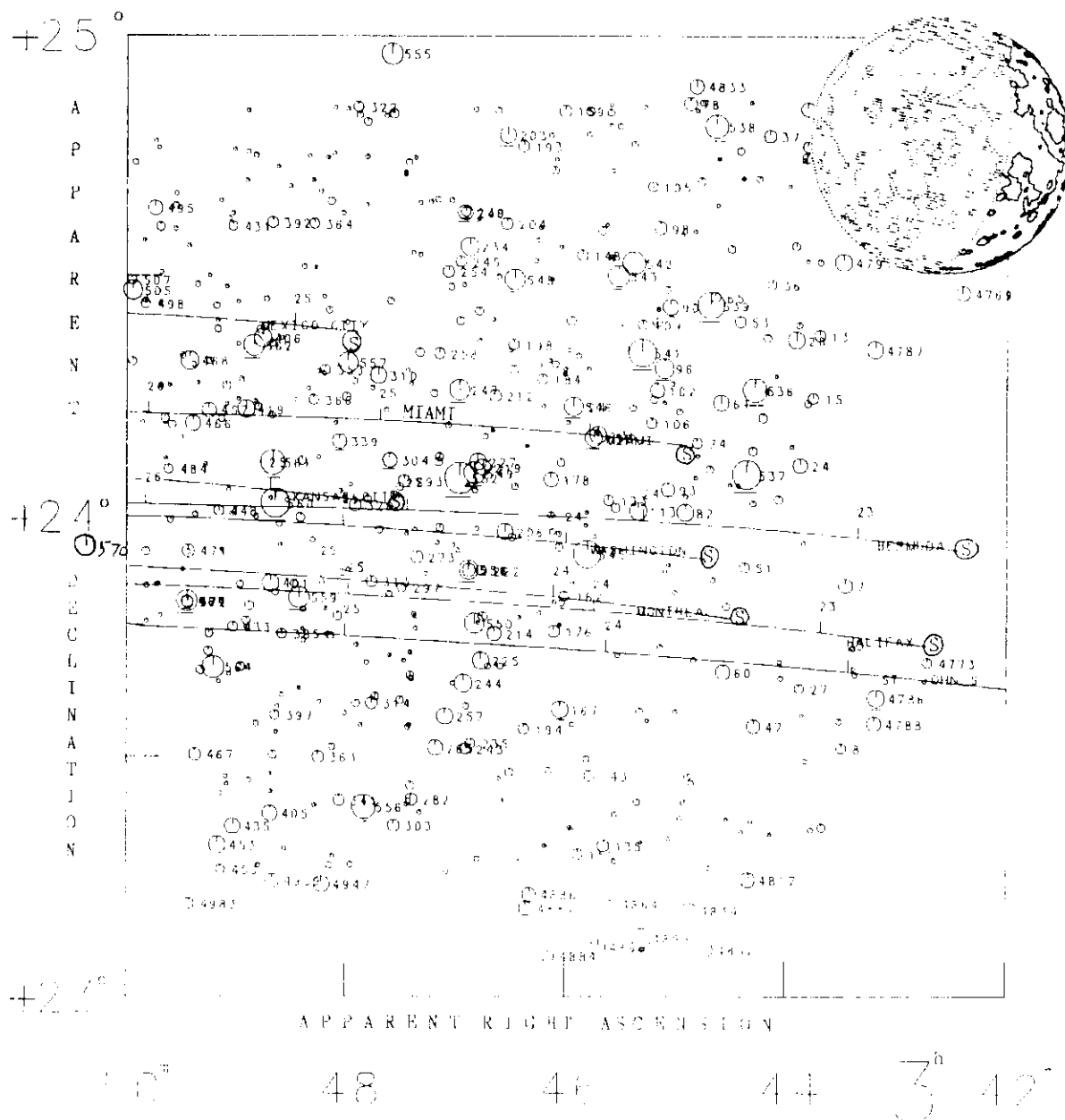
UT date	Nebula	Type	Mag.	diam.	% sunl.	dur.	Area of visibility
Mar. 8, 12 <sup>h</sup>	NGC6293	globular	8.4	1'9	49-	5 <sup>m</sup>	Hawaii
Apr. 19, 12	M35	open	5.3	40	27+	90	Japan, NE. Asia
May 16, 20	M35	open	5.3	40	10+	75	Central Europe
Aug. 7, 0	M35	open	5.3	40	13-	75	Central Europe, Mideast
Sept. 3, 9	M35	open	5.3	40	32-	75	North America
Sept. 15, 11	M19	globular	6.6	4.3	46+	20	Japan, Korea
Sept. 17, 0	M28	globular	7.3	4.7	60+	30	NE. U.S.A., E. Canada
Sept. 30, 14	M35	open	5.3	40	55-	90	Japan (low)
Oct. 14, 0	M8	diffuse	7.0	60	34+	120	South America
Oct. 14, 14	M22	globular	5.9	17	39+	30	India
Nov. 10, 22	M22	globular	5.9	17	18+	30	New England, E. Canada



Observing Priority: The main goal of observations of Pleiades passages is to time as many contacts as possible around the entire circumference of the Moon's disk. Hence, the priority for observing Pleiades passages should be: First, bright-limb graze of Alcyone (and of other bright Pleiads if conditions permit, as they sometimes do during thin crescent phases like this one, but there are no observable bright-limb grazes in the U.S.A. or Canada during this passage); Second, time as many total occultations as you can with the largest-available telescope; during this passage, the reappearance of some of the brighter Pleiades can be timed and would be especially valuable; and third, dark-limb grazes, of which there are many this time.

Use Watts angles (WA's) and a Moon map to locate reappearing stars. The selenographic latitude of the emersion point will be within about a degree of WA - 270° (so that WA = 290° would be at latitude 20° north, near Mare Crisium). Since you generally can not use features right on the edge of the Moon (too foreshortened), but those some distance from it, the Moon's latitude libration of -5° will cause reappearances to appear to occur a few degrees south of where you would expect them from the calculated selenographic latitude.

Grazing Occultations: See my article in the March issue of S&T for information about grazes of the brightest Pleiades stars. In addition, the paths of other good dark-limb northern-limit grazes, visible



with any small telescope, are shown in the RASC's Observer's Handbook and are described, but not identified, in the S&T article. Information specifying them is below:

ZC#	SAO#	mag.	Path
546	76173	7.0	northern Virginia
553	76200	6.8	s. Ohio to s. Virginia
557	76216	6.6	e. Missouri to North Carolina
561*	76229	5.2	n. Ontario to Nova Scotia
562	76236	6.6	Kansas to South Carolina
587	76350	6.4	Washington State to Oklahoma

\*This star is Pleione; the path is near Alcyone's.

Grazes of stars as faint as mag. 8.5 are included in the IOTA grazing occultation predictions, and if conditions are good, they will be readily observable with telescope apertures as small as 6 inches. I had planned to include a map of eastern North America showing all graze limits down to mag. 8.5, but time did not permit it. I will try to distribute a map showing these for the northeastern U.S.A. and southeastern Canada with the A-region grazing occultation predictions for the first half of 1991, which will be sent from USNO probably during the first week of January. Joe Senne will distribute similar maps covering the Midwest in mid January.

If you have plans for expeditions during this passage, please send me a note to the editor's address (not to the address in the S&T article, which is the IOTA secretary's address, not my address), or telephone me at 301,474-4722. An expedition from the DC area is planned for the graze of ZC 546. In some cases, I will infer possible expeditions from my copy of the graze prediction observer scan information for putting on the IOTA occultation message line at 301,474-4945. S&T readers have been referred to this number, so it is a possible source of new observers. I will also try to update the message to give weather prospects and last-minute expedition changes during the two days before the event, but this may be difficult if I am out of town on a probable business trip.

February 21st Passage: I will try to make a chart showing topocentric paths for the February 21st Pleiades passage by a first-quarter Moon that will be very favorable for Europe. If so, it will be distributed with the European grazing occultation supplement for 1991 sometime in January, unfortunately a little late.

#### LARGE 1991 GRAZE SHIFTS EXPLAINED BY ERROR; OTHER GRAZING OCCULTATION PREDICTION NEWS

David W. Dunham

1990 Prediction Error: Puzzling differences in the predictions for northern-limit waning-phase grazes in 1989 and 1990 were briefly described on p. 11 of the last issue. In October and November, Richard Wilds and Don Stockbauer also alerted me to systematic shifts, greater than half an arc second, that were occurring for southern-limit grazes. This was even

more puzzling, since most graze star positions are now accurate to  $\pm 0''.2$  or better, and we had little trouble predicting southern-limit grazes during 1988 and 1989.

The problem was uncovered early in December, as I compared the new lunar ephemeris data based on LE200 (discussed below) with the current ephemeris files used by the basic lunar occultation computer programs at the U. S. Naval Observatory (USNO). I found that the current file was in good agreement with the new LE200 file up to January 4, 1990, but after that, there were large differences. Further checking showed that for January 5, 1990 on, the lunar data in the current file were actually from the inaccurate IIF that we had to use for the limit data for 1991 grazes, mentioned on p. 11 of the last issue. The exact history of how this happened is a mystery, but the declination differences, LE200 ephemeris - currently used one, were confirmed with grazes observed early this month. These declination differences for last part of this month (December 1990), which correspond to shifts that you can expect from your graze predictions (+ for to the north and - for southward), are as follows, for Oh U.T.: Dec. 23, -0''.61; Dec. 25, -0''.40; 27, -0''.09; 28, +0''.10; Dec. 29, +0''.28 (Pleiades passage in North America); and Dec. 31, +0''.58.

1991 Graze Predictions: Thanks mainly to the efforts of Alan Fiala at USNO, we should have accurate graze predictions (when used with the ACLPPP profiles) for 1991 and future years. The system that we have put together for calculating data for 1991 graze profiles, called 80K, with a modification to the ACLPPP program so that it should say "DEC. 1990" version at the top of each profile, should need no corrections. Although I am rather confident of this, it should be proven with observations, so your early 1991 graze observations will be especially important for this purpose. Details of the 80K system are described below.

Fiala, with some help from John Bangert, created a so-called SMBON file (the one used by the main OCC program used to refine graze profile and solar eclipse predictions), first using the ILE ephemeris that generates the whole file, and then replacing the lunar data (given in the form of apparent place positions) with the accurate LE200 lunar ephemeris data that were determined by fitting a numerically integrated lunar ephemeris to lunar laser ranging observations. A predecessor to LE200, called PMX04, was used by Tom Van Flandern for the last analysis of lunar occultations that he performed about 1980, and was in the file up to, as we know now, Jan. 4, 1990.

Fiala created the new (LE200) file for 1987 - 1991. Comparisons of PMX04 and LE200 for several dates in 1987 and 1989 always showed agreement to better than 0''.1 in declination, whereas there was a near constant difference in right ascension, +0.020 +0.001 second of time, in the sense, LE200 - PMX04. The 2.4" difference is explained by the fact that PMX04 was generated on the B1950 equinox system, whereas LE200 uses the new J2000 system. The zero points of lunar right ascensions are known to differ; in fact, the J2000 zero point was largely determined by analysis of lunar occultation observations. Since the 1950

program already automatically applies corrections to the right ascensions, assuming that they are on the B1950 system, I created a new version (XZ80K) version of the XZ catalog, which is the same as XZ80J only with 0.020 added to the seconds of R.A. of all of the stars. This will compensate for LE200's being on the J2000 system, at least for the early 1990's; a change will be needed later, since the rate as well as the zero point of R.A. is known to differ between J2000 and B1950. Note that this XZ80K catalog is not the "future version of the XZ" called "XZ80K" mentioned in QN 4 (11), p. 260 (1989 March); the recommended changes mentioned there have not been made to the XZ catalogs used at USNO.

Possible Future OCC Replacement: As mentioned on p. 11 of the last issue, Mitsuru Soma, Japanese National Observatory, Mitaka, Tokyo, is working on a new analysis of lunar occultation observations, and programs incorporating corrections that will be obtained from this analysis that will replace some of the important functions of USNO's OCC program. This should result in a further improvement in knowledge of corrections to Watts' profile data and also in our predictions because the XZ star positions and proper motions have been improved considerably since the last analyses were performed a decade ago. When Soma was at USNO on October 22, we discussed the detailed requirements for his new software to perform some OCC functions, and he thought that he might have it ready by February. However, now that the 80K system has been established at USNO, there is not a strong urgency for replacement, and Soma's work might be delayed to await creation of an improved XZ catalog, to include the corrections mentioned in the 1989 March article as well as new star catalog data with improved positional data, including the final Zodiacal Zone and PPM catalogs.

Reports of Magnitude Discrepancies Sought: The improved XZ catalog noted above will also have improved magnitudes (especially, some correction of the photographic magnitudes given for AGK3 stars), so your reports of observed discrepancies in the magnitudes of occulted stars are welcome. For example, Yuri Moskalenko in Lubny, Ukraine, USSR, recently sent a report of six discordant magnitudes of XZ stars from his occultation observations observed during 1989 and 1990.

---

#### GRAZING OCCULTATIONS

Don Stockbauer

My goals as coordinator of IOTA's lunar grazing occultation section were given on p. 9 of the last issue. In addition, when a large shift due to star position error (0.5 or greater) is reported, I try to notify active expedition leaders who are selected for nearby future grazes of the same star, obtained from comprehensive observer scan data sorted by star number provided by David Dunham. Read especially the 2nd-to-last paragraph of this article; your recent graze reports are valuable.

Please send copies of grazing occultation reports to me at: 2846 Mayflower Landing; Webster, TX 77598;

USA. If a copy can be sent to the International Lunar Occultation Centre (ILOC), this is greatly appreciated; their address is: Geodesy and Geophysics Division; Hydrographic Department; Tsukiji-5, Chuo-ku; Tokyo, 104 Japan. For graze reports on diskette, please send me a printed copy of the data file only and send the actual diskette to ILOC. Total occultation reports on any medium need only be sent to ILOC (unless a possible new double star is found; see Murray's article on p. xx).

Unusually large shifts for southern-limit grazes have been reported during the past few months. Particularly large shifts on 9/25/90 and 9/26/1990 are listed in the current table. These have now been explained (see Dunham's article above) and should not continue during 1991.

For the graze of Jupiter at Bellver, Spain on 8/18/90, the number of timings (7) represents only second and third contacts, not first and fourth. Another factor that can reduce the number of timings in the table when compared to the total entered on the form under #TM is the fact that certainty 1 codes count as a full timing, code 2's count as one-half, and code 3's count as zero (which is only reasonable). However, in the rush to produce this article, this is sometimes not double-checked very well and incorrect statistics can sometimes creep in. This and other details of filling out the form may be found in the paper "Use of Form for Recording Occultation Observations", available from me upon request.

Benny Roberts writes that Jim Waltman had to find a site for the 10/31/90 graze of ZC 3512 at Florence, MS based only on Benny's general description of the area before the event due to his arriving slightly late at the meeting place. In spite of this, he saw more events that Benny (6 versus 4; however, Jim's tape recorder failed and no data was obtained). Benny has decided that a better method of graze site selection than cool, scientific, rational planning might be to just tape the topographic map to a wall and throw darts into it, something I've often felt like doing after hours of tedious expedition planning. Benny was not able to derive a shift based on his four timings because the predicted profile was completely unlike the observed data. There is a discontinuity at Watts angle 161° for latitude librations near -5° measuring 0.5 arc seconds between points coded "\*" and points coded "5". Even shifting the two strings of points into alignment does not permit a good fit of his data. This area is a prime candidate for updating using either past or future observations.

This demonstrates one of the main value of grazing occultation observations, to make individual and systematic regional corrections to Watts' lunar profile data. This in turn helps obtain better results from analyses of total and graze observations for determining individual and systematic corrections to catalog star positions, and their reference system; and from analyses of solar eclipse Bailey's bead and inner contact timings to determine small Solar diameter variations. Since Mitsuru Soma at the Japanese National Observatory plans to do a complete reanalysis of all available total and grazing occultation observations for the above purposes using

improved star catalog data during the next few months (see the 2nd-to-last paragraph of Dunham's graze prediction article above), please try to send me any of your unreported graze observations in the next

#### Graze List as of 11/20/1990

Date	V	Star	%	#	#	S	Ap	N
YrMoDy	P	#	Mag.	Sn1	CA	Location	Sta Tm S Cm Organizer	CShS WA B
900716		0311	6.5	39-	10N	Hubbell, NE	5 28 1 20	Richard P. Wilds 8N352-61
900718	V	076259	7.3	21-	7N	Shipbourne, Eng.	10 51 1 9	H.J.T. Carpenter 0357-54
900813		0370	6.1	57-	6N	Jasien, Poland	7 38 1 8	Janusz Slusarczyk 353
900813		0387	6.9	56-	7N	Driebruggen, Neth.	1 2 1 20	Henk Bulder 0353-62
900814		0541	4.0	43-	5N	Keene, KS	1 0 3 33	Richard P. Wilds 0356-55
900814		0541	4.0	43-	5N	Solon, IA	5 20 1 15	William J. Eby 1S356-55
900814		0541	4.0	43-	6N	Epoufette, MI	2 22 1 6	Craig A. McManus 0355-55
900816		078009	9.0	19-	7N	Manzanita Obs, CA	1 10 1 20	Richard P. Wilds 0356-36
900817		1030	3.2	14-	5N	Fraimbois, France	4 12 2 11	Jean Schwaenen 4S359-25
900818		Jupitr	-1.9	5-	15S	Bellver, Spain	4 7 3 20	Carles Schnabel 17-02
900828		2276	5.6	48+	8S	Greeley, KS	2 8 1 20	Craig A. McManus 1S171 70
900828		2276	5.6	48+	8S	Freeman, MO	6 38 2 8	Robert Sandy 5S172 70
900909		0370	6.1	78-	6N	Prescott, KS	4 35 1 20	Richard P. Wilds 0351-60
900909		0370	6.1	78-	6N	Warrensburg, MO	2 17 1 9	Robert Sandy 0351-60
900909		0370	6.1	78-	6N	Duplainville, WI	4 16 2 25	G. Samolyk 351-60
900913		X09000	10.4	37-	3N	Zoetermeer, Neth.	1 1 1 30	Henk Bulder 359-25
900925		185041	8.3	38+	11S	Areias Gor., Port.	3 5 1 13	Joaquim Garcia 24S169 57
900926		185274	8.3	40+	10S	Seneca, KS	3 7 1 20	Richard P. Wilds 18S171 55
900930		3058	5.9	78+	16S	Dannebrog, NE	1 2 1 33	Richard P. Wilds 5S163 1
901001		3186	6.7	86+	18S	Elmont, KS	5 13 1 20	Richard P. Wilds 2S162-14
901001		3186	6.7	86+	18S	Amazonia, MO	4 17 1 8	Robert Sandy 2S162-14
901024		185976	8.4	24+	17S	Rantoul, KS	1 2 1 33	Richard P. Wilds 8S164 44
901026		188423	8.0	42+	15S	Frankfort, KS	3 18 1 20	Richard P. Wilds 5S164 19
901026		2884	7.5	42+	17S	Frankfort, KS	4 26 1 20	Richard P. Wilds 5S162 16
901026		2884	7.5	42+	17S	Craig, MO	2 18 2 9	Robert Sandy 1S162 16
901028		164870	7.5	71+	15S	Conyers, GA	1 4 1 25	Mike Kazmierczak 0165-23
901031		3512	5.8	89+	22S	Florence, MS	1 4 1 33	Benny Roberts 163-50
901110		118037	8.4	41-	6S	Fredonia, KS	5 13 1 20	Richard P. Wilds 4N187 3

#### SOLAR ECLIPSE NEWS

David W. Dunham

1991 January 15: Several Germans led by Hans Bode will spend 3 weeks in Australia and New Zealand, recording the annular eclipse from both limits in New Zealand with video equipment. Bode will be at the southern limit near Christchurch, while Paul Maley will join their northern-limit effort north of Wellington. Graham Blow in Wellington is handling the local logistical arrangements and providing a contact point. Derald and Denise Nye will spend at least as much time in Australia, and will join the IOTA group expedition coordinated by Martin George to videorecord the eclipse at the southern limit in Tasmania, probably near Hobart. Alan Fiala from USNO is sending his video equipment to USNO's station near Black Birch, New Zealand, to be used by one of their employees, who will join the northern-limit effort with Paul Maley and some of the German observers. Alan Fiala could use the XZ80K version of the OCC program described in my article on p. xx to calculate detailed predictions of the eclipse limits. This should give predictions about as accurate as those for other eclipses that we have computed during the 1980's, which had errors in ecliptic latitude of up to 0".5. It should be possible to compute more accurate predictions, better than have ever been

couple of months. I will forward them on to Soma, who would like to have accurate recent occultation observations, especially of grazes.

Thanks for the reports; Richard Wilds is clearly the winner this quarter. See you next issue.

computed before, by replacing the solar data (which are based on Newcomb's work a century ago) in the SMBDN file with a modern solar ephemeris, such as that from JPL's DE200 planetary ephemerides. Fiala is attempting to do this, and in any case will send detailed predictions (by fax and e-mail, if necessary) to Graham Blow in New Zealand and David Herald in Australia. They will distribute these to expedition leaders in their countries.

1991 July 11: I have been so busy with other matters, especially getting out this issue and prediction data for 1991 occultations, that I have not had time to do anything about additional plans for this great total eclipse, or the spectacular Pleiades passage in Mexico three days before. So see p. 13 and 14 of the last issue for "the latest" information. So far, no concrete plans have been made to observe any of the Pleiades grazes, nor near the northern limit in either Baja or near Mazatlan. If you are interested in either of these, contact me at 7006 Megan Lane; Greenbelt, MD 20770, or phone me at 301,474-4722. During January, I will compute detailed predictions for the important Pleiades grazes, and order appropriate maps for them and for the eclipse limits; I already have 1:50,000-scale maps of the northern limit across Baja, and some coverage of the eclipse limits on the mainland as well, although the latter is not complete. I will then distribute the predictions, and information about weather

prospects, maps, and logistics that I obtain, to those interested. I need to know who wants to go to the northern limits of either the eclipse in Mexico or of any of the Pleiades grazes there, so that the efforts can be coordinated and appropriate logistics might be worked out. By the time the next ON is distributed, all flights into Puerto Vallarta will probably be booked, so arrangements to join either Maley's or Van Flandern's expeditions should be made well before then, probably within the next month.

For the eclipse limits experiment, we will not position any ON subscribers where they might have a miss. Considering all error sources, observers will be positioned at least 1 mile inside the path of totality to guarantee some totality. Some "limit" observers may be positioned as much as 4 miles inside the path, which will still give strong limit geometry for those who also want to photograph the corona. We might try to organize local school children or workers to form chains to straddle the limits, as was done successfully in Java in 1983 to establish where the eclipse was and was not total, but we will not suggest this for any amateur or professional astronomers, or anyone who has travelled any significant distance for the eclipse.

1992 January 4: Hans Bode and Paul Maley are interested in planning expeditions for this annular eclipse in the Pacific Ocean, and will try to locate islands close enough to the limits of annularity for useful observations.

---

#### IOTA/ES ANNUAL MEETING Eberhard H. R. Bredner

The following is a short report of our annual meeting, held in Hannover on October 27th.

Association regularities: President Hans Bode gave a short report of current activities. IOTA/ES will try to get more articles in astronomical journals as association-information.

The board of directors was re-elected. Our new (and old) staff is:

Hans-Joachim Bode, President  
(Bartold-Knaust-Str. 8, D-3000 Hannover 91, Germany)  
Wolfgang Beisker, Scientific Manager  
(Max-Planck-Str. 13, D-8056 Neufahrn, Germany)  
Alfons Gabel, Treasurer  
(Gartenstrasse 8, D-6501 Klein-Winternheim, Germany)  
Eberhard Reidel, Public Relations Manager  
(Linderblick 34, D-2300 Molfsee, Germany)  
Eberhard Bredner, Secretary  
(PO Box 2449; D-4700 Hamm 1, Germany)

The membership fee for 1991 will remain DM 40.-; if there are problems for members from "eastern states of Europe", the president can give them the status "honorable membership". From now on the fee has to be paid before January 1 for the next fiscal year. [See from the Publisher, pg 25, on how and where to pay.]

IOTA/ES will buy a computer to reduce occultation

observations to provide rapid response to observer reports. We will build some CCD devices designed by Wolfgang Beisker. They will be offered in two forms: as a kit for about \$150 US, boxed and ready to use about \$200 US (price for members only).

The next ESOP conferences: ESOP X in Hannover (750th year of freedom of the city), ESOP XI in Florence, Italy (350th anniversary of the death of Galileo). Further meetings are (tentatively): ESOP XII in Austria, ESOP XII in the Netherlands.

Scientific Program: Reports were given of the regional meeting in Eilenburg (see p. 54) and in St. Niklaas (see below).

The status of the reduction of the Titan occultation (eleven video tapes) was discussed. The reduction being attempted by Wolfgang Beisker is very difficult due to the volume of data. We will try to get support from professional astronomers.

We have Watts Charts in machine-readable form for use in occultation observation reduction. We hope to use our reductions to improve the lunar profile data.

The next expeditions of IOTA/ES are:  
1991 January - New Zealand for the annular eclipse of the Sun  
1991 February - Mexico and  
1991 April - Morocco for grazes of Antares  
1991 July - Mexico for total eclipse of the Sun

Anyone desiring to join these expeditions should contact Hans Bode.

---

#### ANNUAL MEETING OF OCCULTATION OBSERVERS IN BELGIUM

Eberhard Bredner

Over the years it has become a tradition of occultation observers in the lower countries (The Netherlands and Belgium) to meet once a year to discuss results of occultation work, exchange information about experiences, and to plan graze expeditions for the coming year. This year the meeting took place on October 13 in a nice restaurant at the market place of St. Niklaas in Belgium. Besides 33 members and representatives of VVS, APEX, CAB, NADIR, NVWS, and EAON, I attended this meeting as secretary of IOTA/ES to learn how to set up a similar organization in Germany and to participate in the grazing expeditions, if that would be possible and not too far to travel.

The meeting started with a word of welcome by Pierre Vingerhouts, president of the occultation working group of the VVS who organized this meeting together with his family (!). The first paper was presented by Henk Bulder on behalf of NADIR on the results of several successful graze expeditions in 1990. Jean Meeus presented his method of predicting occultations. Roland Boninsegna, president of EAON, followed with a paper on the successful occultation of the star SAO 147658 by asteroid (521) Brixia on October 23, 1989. Jean Meeus took the stand again to present his reduction work for occultations of the VVS before

they are sent to the ILOC. Pierre Vingerhoets' paper concerned the successful graze expeditions of the VVS, APEX, and CAB in 1990. Adri Gerritsen presented the NVWS expedition results. In all 1990 has granted 11 successful expeditions so far. Henk Bulder finished the row of speakers with his talk about combining the results of several expeditions. He made some useful suggestions about improving the setting-up of expeditions in order to minimize the chances for a miss.

After a break for informal contacts, a lunch ("coq au vin") was served. Henk Bulder brought some wine (a good Bordeaux from France) to celebrate the fact he reached 2000 occultation observations in September this year after 13 years of active observing.

After the lunch, the meeting was continued planning the grazes of 1991. Calculations from Jean Meeus and the USNO lists served as guides. Some 30 expeditions were agreed upon, even more than in 1990, with the main event being the Pleiades passage of February 23rd 1991. The intersection point of two bright grazes is well placed near the border of the Netherlands and Belgium. Suggestions of Ignace Naudts to seize this Pleiades passage to serve as a promotion campaign for occultation work were honored. Experienced observers will guide novices to show how they can contribute to science in a simple way. To stimulate them results will be compared immediately afterwards. Finally there was some discussion about CCD cameras for amateur use. Results of the IOTA/ES meeting in late October in Germany (Hannover) may well result in a joint effort. Closing the meeting, Pierre Vingerhoets thanked all participants for their contribution to this fruitful day.

(Thanks to Henk Bulder for his support in preparing this article.)

#### SOLAR SYSTEM OCCULTATIONS DURING 1991

David W. Dunham

**General:** My predictions of occultations of stars by major and minor planets are given in two tables whose contents are described in subsequent sections of this article. Most of the asteroidal occultation prediction material distributed by IOTA was prepared by Edwin Goffin in Belgium and is discussed in the third section. Sources of the predictions, other information, including stellar diameters (when significant) and a priority list, and notes about individual events, are given in the last sections.

**Reporting Observations:** Reports of observations of any of these events should be sent to Jim Stamm; 11781 N. Joi Drive; Tucson, AZ 85737; U.S.A. (see his article on p. 26). Report positive or negative observations made under good conditions, but clouded-out attempts need not be reported. If a definite occultation is seen that could use some analysis for comparison with others, also send copies of the report to me at 7006 Megan Lane; Greenbelt, MD 20770; U.S.A., and to the chairman of the International Astronomical Union's (I.A.U.) Commission 20 Working Group on Predictions of Occultations by

Satellites and Minor Planets, who is Lawrence Wasserman; Lowell Observatory; Mars Hill Road, 1400 West; Flagstaff, AZ 86001; U.S.A. Alternatively, observers may send their reports to their local or regional coordinators, who can then send the results to Stamm, and, when appropriate, to Lowell Observatory. The addresses of the regional coordinators are given in "From the Publisher" on p. 25 of this issue. Forms for reporting the observations can be obtained from Stamm or from the regional coordinators. Please indicate on the forms to whom copies are being sent. These forms are preferred, but the forms of the International Lunar Occultation Centre (ILOC), or the equivalent IOTA/ILOC graze report forms, can be used for reporting timed occultations or appulses. The main difference from reporting lunar events is that the name of the occulting body should be written prominently at the top of the form, and the report should be sent to neither ILOC in Japan nor to Don Stockbauer. Also, if the asteroid is visible, the time that it merged with the star to form one apparent object, and the time the two were again noticeably separated, should be reported, with an estimate of whether the asteroid passed north or south of the star, if possible. Copies of the ILOC forms can be obtained from ILOC, the IOTA secretary-treasurer (the McManises in Topeka, KS), or from Don Stockbauer; 2846 Mayflower Landing; Webster, TX 77598; U.S.A.

**Asteroidal Occultation Predictions by F. Goffin:** The 1991 Asteroidal Occultation Supplement for North American Observers, prepared by Edwin Goffin with finder charts annotated by David Werner, were distributed with the last issue of *ON* for IOTA members and *ON* subscribers in North America. Copies of Goffin's predictions and charts applicable to other parts of the world were sent by Jim Stamm a few months ago to regional coordinators for distribution to members and subscribers in their regions. Goffin has continued to improve the orbits for many asteroids, and we have both used these for our predictions. Goffin used my Combined Catalog (CC), and my version of Fresneau's Astrogaphic Catalog (FAC), for most of his calculations, so many of our predicted events are in common, and our predicted paths for the common events are generally in good agreement. Consequently, we need to publish only a few finder charts in the regular issues of *ON*, since they have already been distributed with Goffin's predictions. In a few cases, we will publish 1° charts for some of the more crowded star fields on Goffin's charts, to facilitate locating the star to be occulted (the "target star"). These will be published alone, to be used in conjunction with Goffin's broader-field charts. Remember that the 1° charts are generated mostly from FAC.

Comparison with the True Visual Magnitude Atlas (TVMA) often shows that some FAC stars are brighter, fainter, or very faint relative to their plotted magnitudes, indicated with B, F, or VF, respectively. "N" indicates that the star is not shown in TVMA.

There are a few minor problems with Goffin's use of the CC and FAC. The most significant problem was caused by an error that I made in creating the CC: The sign of the proper motion in declination of Yale catalog stars was inadvertently omitted. This is usually not a serious problem, since correct data for virtually all Yale stars are given in the SAO and

other catalogs, all of which had more priority than Yale when CC was created. The main purpose for merging Yale into CC was to obtain a few hundred Yale stars with southern declinations whose proper motions were not determined (zero used) and which are not in the SAO or most other catalogs. For stars with large negative proper motion in declination, the coordinate matching used to create CC did not work, resulting in many "false" stars whose only source was Yale. Only a few of Goffin's 1991 predictions involve these "false" stars, so the actual occultations will not be visible from the Earth's surface, including the path for the occultation of SAO 184425 by (674) Rachele on May 27 is still on the Earth's surface, but far north of Goffin's track; correct data for that event are given in this article. Another of Goffin's events that will not occur involves FAC 199379 by (121) Hermione on April 11. The old FAC position is now off due to large proper motions; the star is SAO 78108 and a calculation with data from the ZZ87 catalog shows that the path will be off the Earth's surface several hundred kilometers above Alaska. These were not included in the North American supplement, but were sent to Graham Blow in New Zealand. Also, Goffin assigned sequential numbers to some of the catalog sources, including the FAC, where the stars remain unnumbered in my version. For the five different Lick-Voyager catalogs, he used my original source catalog number, rather than the sequential numbers for the five catalogs given in the DM number column, which are used by Lowell Observatory in their publications as well as by me. For the same reason, our designations for the Astrographic Catalog (AC) stars in the CC differ.

Explanation of data in Table 1: Read especially the important discussion about  $\Delta_m$  given in the last paragraph of this section. The ranges of Universal Time give the time of central occultation (apparent closest approach to the center of the object) as seen from the predicted central line while it is on the Earth's surface and, except for bright stars, not in daylight. Only one time is given if the occultation shadow is on the Earth's surface in darkness (except for very bright stars) for less than two minutes. See also the next paragraph about Possible Path if there is a slash (/) after the date. Under PLANEI,  $m_v$  is the visual magnitude (photoelectric V-mag, when available), and  $\Delta$  is the geocentric distance in astronomical units. For calculating  $m_v$  for asteroids, I have not used the new H and G magnitudes, using instead the B and B-V magnitudes published in the 1979 Asteroids book. I have not had time to update my computer programs to include the more complex H and G magnitude calculations, and my database of asteroid physical and orbital information. Under STAR,  $m_v$  is the visual magnitude (photoelectric V-mag, when available), except when the source is AC or AGK3, when a photographic magnitude, closer to B-mag., is given. The star's spectral type, sp, and its approximate equinox 1950 position are also given. If a star does not have an SAO number, see the DM/Id number in Table 2 for its preferred designation. Under OCCULTATION,  $\Delta_m$  is the change in visual magnitude of the coalesced images that is expected if an occultation does occur, dur is the duration of a central occultation computed using the expected diameter of the occulting object. My central durations often differ from those published

by Goffin and by Lowell Observatory, since I usually use asteroid diameters obtained by the IRAS satellite published on pages 1090 - 1138 of Asteroids II (R. Binzel, T. Gehrels, and M. S. Matthews, eds., Univ. of Ariz. Press, 1989), rather than the TRIAD diameters from the 1979 Asteroids book used by the others. In some cases, better diameters derived from previous occultations have been used. The  $df$  is a measure of the diffraction effects for a central occultation (it is the time in milliseconds between fringes for an airless planet; depending on the brightness of the star, a visual observer can notice a gradual fade or brightening of the star for 2 or 3 times  $df$ , which also can be magnified greatly by a nearly grazing geometry), and  $P$  is the inverse of the probability that an occultation will occur at a given place in the possible area, assuming a combined stellar-ephemeris positional error of 1"0 (that is,  $P$  is essentially the ratio of the width of the possible area of visibility to the expected width of the occultation path). The combined positional error, and consequently both the possible area of visibility and  $P$ , can be reduced considerably by last-minute astrometric photographs, preferably with the asteroid and star on the same plate, which may be possible only 2 or 3 days before the event. No values are listed under  $\Delta_m$  for occultations by major planets, except in the cases where the star is less than five magnitudes fainter than the planets. The extent of the planet, and the fact that events can occur against its dark side, make  $\Delta_m$  meaningless for most occultations by major planets.

Under Possible Path, three pairs of numbers are listed, giving in integral degrees the longitude ( $Lo$ , east of Greenwich positive) and latitude ( $La$ ) of the first (suffix "l"), middle ("m"), and last (or end, "e") points of the predicted observable occultation path, respectively. The corresponding central times for the first and last points are given under the Universal Time column. The path coordinates can be used to locate the paths on my quarterly maps showing the paths of all events worldwide, just as the coordinates for the center of graze paths are used to locate lunar occultation limits plotted in the grazing occultation supplements. You should know your own longitude and latitude so that you can tell which events are near you, but it is easier to estimate this from the direct calculations in the local circumstance predictions distributed by Carroll and Bode, or from examination of the regional maps. If the centerline of the occultation misses the Earth's surface, I have manually inserted a description of the possible region of visibility, enclosed in parentheses and followed by a ? and either an "n" or "s" to indicate whether a northward or southward correction, or shift, from the nominal path is needed to move the path into the possible area. A slash (/) given after a few dates indicates events that, for some unknown reason, are not plotted on my quarterly maps of the Western Hemisphere; Europe, Africa, and Middle East; and Australasia; although they should have been. Often, these events involve major planets whose centerlines miss the Earth and whose region of visibility is described under Possible Path. Also not on the quarterly maps are polar-region paths entirely north of latitude +65° or south of latitude -50°, and all asteroidal occultations where the path does not intersect the Earth's surface at locations

where the star is sufficiently above the horizon and the Sun enough below it for possible observation.

After Possible Path, the elongation of the Sun from the target star is given under the E1 Sun column. Under Moon, the elongation from the target star is

given under E1, the percent sunlit ("+" for waxing and "-" for waning phases) is given under %Sun, and the longitudes from which the Moon will be above the horizon along the possible path are specified under Up. For the latter, the moonrise or moonset terminator is specified in degrees of longitude E(ast) or

Table 1 part A

1991 Universal Date	Time	P L A Name	$\Delta\alpha$ h m s	$\Delta\delta$ ° ' "	S RA (1950) h m s	T Sp R <sub>z</sub> A <sub>z</sub> (1950) Dec. ° ' "	Occultation $\Delta m$ dur df	Possible Path LoLaLa LonLat LonLat	E1 LoLaE Sun	M E1	O %Sun	Up	Ephem. Source
Jan 1	22 <sup>h</sup> 6-10 <sup>m</sup>	Lurina	12.8	2.447	10.8	F8 13 <sup>h</sup> 3 <sup>m</sup> 2 <sup>s</sup>	8.27 <sup>h</sup>	52° 16' 72" 18° 11' 13" 18° 35° 75"	90-	40-	all	MPC15334	
Jan 3	19 28-40	Hermione	12.2	2.418	11.3	5 57.6 26 55	1.3 16 23 15	105-29 57-11 0-16 167 55	97-	87-	e 24E	MPC12137	
Jan 3	23 58-102	Vesta	7.4	1.908	93228	F4 F5	20 27 0.8 145 70 5	-65-29 -75 18-159 70 122 101	36-	36-	none	Goffin85	
Jan 3	13 16-30	Hercules	10.9	1.636	10.9	6 40.5 20 14	0.2 16 19 11	-133 -1 174 29 69 48 175 68	72-	68	e128E	Goffin88	
Jan 7	2 34-49	Thetis	11.9	1.832	9.5	6 3.0 19 13	2.5 7 21 29	21-12 -36 7-113 8 164 97	57-	57-	e 46W	Goffin87	
Jan 9	10 43-56	Hermione	12.3	2.449	10.8	5 53.1 27 2	1.8 17 25 16	-99 23-151 44 112 42 160 129	34-	34-	e128W	MPC12191	
Jan 9	13 38-54	Eunike	11.8	1.969	10.3	K5 9 19.0	1 16 1.4 16 26 17	-149-36 166 -7 112 16 144 76	33-	33-	e166E	MPC14753	
Jan 9	20 56-80	Fortuna	10.2	1.280	10.2	5 47.7 20 56	0.6 23 30 11	92 -2 42 10 -30 4 158 134	30-	30-	e 63E	MPC13923	
Jan 10	14 45-64	Hestia	12.5	1.714	11.9	2 58.0 13 51	1.1 22 43 19	55 27 34 39 146 45 117 171	24-	24-	none	Yeomans	
Jan 10	18 35-48	Parthenope	10.3	1.689	9.8	A3 7 50.9 19 31	1.0 13 20 15	168 19 112 44 0 51 173 117	23-	23-	e133E	MPC12686	
Jan 11	17 5-17	Deiopaia	12.8	2.091	79496	10.1 A2	7 30.2 22 58 2.8 5	158-32 108-14 41-19 179 133	16-	16-	e133E	EMP 1983	
Jan 12	13 6-23	Lydia	11.9	1.881	78343	8.6 G0	6 22.3 29 36 3.1 8	23 31 -133 -0 168 25 79 17 162 159	19-	19-	e142W	MPC14752	
Jan 13	11 50-63	Myrrha	13.5	2.565	95912	1.9 A0	6 34.8 16 27 11.6 8	-113 -7 179 19 79 25 165 163	6-	6-	e113W	MPC14161	
Jan 14	14 53-68	Herculina	9.2	1.641	12.0	6 31.3 21 21	0.08 17 20 11	-178-16 123 17 50 35 164 176	2-	2-	none	Goffin83	
Jan 14	17 49-59	Herculina	9.2	1.641	12.3	6 31.2 21 22	0.06 17 20 11	103-50 69-24 19 -7 164 176	1-	1-	none	Goffin88	
Jan 15	2 0-1	Ida	15.4	3.196	10.1	23 30.2 -2 26 5.3 1	11 140	-128 58-128 58-102 65 58 68	1-	1-	none	Yeomans	
Jan 17	21 14-25	Parthenope	10.3	1.688	10.4	F5 7 43.6 20 2	0.7 12 20 15	79-48 34-26 -25-23 177 156	3+	3+	w 18W	MPC12686	
Jan 17	22 49-64	Herculina	9.2	1.649	8.7	F0 6 28.1 21 45	1.1 18 21 11	52-41 2 -7 -70 13 160 138	4+	4+	w 51W	Goffin88	
Jan 18	0 3-4	Interannia	11.5	2.923	11.5	23 27.6 13 11	0.7 10 10 13	-73 3 -73 3 -54 2 62 40	4+	4+	w 64W	Schmadel	
Jan 19	1 31-44	Herculina	9.3	1.652	10.5	6 27.1 21 53	0.3 18 21 11	-6-42 -44-14-102 5 158 124	19+	19+	w 76W	Goffin88	
Jan 19	5 9-23	Kleopatra	10.5	1.567	11.2	9.1 G5 7 18.0 1 11	1.7 13 23 17	-11 31 -65 40-154 54 158 134	13+	13+	w142W	Goffin89	
Jan 19	11 8-22	Patience	11.7	2.325	11.2	3 19.1 11 39	1.0 26 34 15	116 4 126 32-176 71 112 73	1+	1+	w137E	MPC15529	
Jan 19	15 45-55	Tetris	12.1	1.592	94985	5.9 B2	5 52.0 19 44	126-53 88-36 36-28 149 108	13+	13+	w 59E	Goffin87	
Jan 21	4 26-35	Athamantis	11.6	1.572	156976	8.2 A3	11 43.7 -11 45 3.5 30	61 21 38 48 32 41 23 19 118 172	25+	25+	none	MPC11508	
Jan 23	10 4	Lemna	12.8	3.177	146465	6.1 M0	22 59.9 -6 51 5.7 3	central Suenia 23 41 47	48+	48+	all	Goffin87	
Jan 26	4 19-35	Circus	11.6	1.442	10.1	3 39.3 10 26	1.7 12 23 18	15 14 -38 34-138 51 171 61 78+	19+	19+	w 19+	MPC1324	
Jan 26	15 34-50	Herculina	9.4	1.683	11.4	6 20.9 22 46	0.2 21 25 11	165 -1 127 27 38 52 149 19	83+	83+	all	Goffin88	
Jan 28	1 54-55	Nezithys	13.0	2.980	146799	7.4 F5	23 33.4 -9 3 5.7 2	-111 27-111 27 -89 33 44 157 93+	93+	93+	all	EMP 1983	
Jan 30	2 42-62	Euterpe	9.2	1.029	9.8	K0 8 57.4 19 8	0.5 15 25 13	8-43 -41-18-107-11 177 5 109+	109+	109+	all	EMP 1987	
Jan 31	21 58-76	Antagone	12.1	1.651	157542	8.3 F5	12 48.0 -10 18 3.4 10	19 0 45-17 76-45 116 42 96-	96-	96-	all	MPC11507	
Feb 2	3 10-14	Hestia	13.0	2.022	11.7	3 14.0 15 16	1.6 9 19 22	-131 47-106 52 -49 51 98 119	39-	39-	e106W	Yeomans	
Feb 2	9 50-90	Astraea	9.6	1.208	95089	6.3 B9	5 43.4 18 54	-129-47-173-17 124 13 148 73	87-	87-	e153E	Goffin86	
Feb 3	3 43-66	Hermione	12.7	2.682	12.1	5 40.2 27 17	1.1 47 70 13	-5 43 -42 61-164 70 132 99	82-	82-	e 71W	MPC12191	
Feb 4	22 1-12	Penelope	12.5	2.121	10.5	G5 8 55.7 13 52	2.2 5 19 43	77-45 24-20 -43 -3 176 74	66-	66-	e 1W	MPC15523	
Feb 5	17 29-45	Lurina	12.3	2.000	12.5	13 28.8 9 10	0.7 21 41 21	108-37 136-22 174 6 117 30 53-	53-	53-	all	MPC15384	
Feb 5	22 33-34	Juova	13.6	3.422	92170	8.5 G5	0 54.1 11 26	-58 18 -43 20 -16 19 61 158	56-	56-	none	MPC12303	
Feb 10	7 46-67	Tetris	12.4	2.086	10.5	5 42.2 20 33	2.1 29 39 33	-163-52-173-37 164-19 125 173	17-	17-	none	Goffin87	
Feb 15	12 50-54	Lamberta	11.8	1.713	158961	9.4 K0	14 57.5 -16 21 2.5 8	150 47-133 36-104 15 99 109	1-	1-	none	MPC11520	
Feb 20	17 16-27	Eunike	11.7	1.932	10.1	8 46.7 8 6	1.8 11 18 17	105-62 71-25 23 13 159 98	36+	36+	w 71E	MPC14753	
Feb 21	17 56-63	Mars	0.4	1.143	76660	9.1 A2	4 31.8 24 9	6 37 42 37 95 23 98 11 48+	48+	48+	all	IA0001	
Feb 22	22 32-36	Carlova	12.8	2.120	94367	8.3 F8	5 7.8 15 13	-57 52 -33 52 50 65 104 11 61+	61+	61+	all	MPC14754	
Mar 1	7 10-12	Arsinoe	13.0	1.979	160372	8.0 G5	17 10.4 -12 40 4.9 4	-90-13 -71-17 -32-26 82 92 100-	100-	100-	all	MPC14930	
Mar 2	1 6-35	Kleopatra	11.3	1.937	11.5	7 0.1 4 47	0.6 23 46 21	-75-45 -63 1 -13 58 123 71 98-	98-	98-	all	Goffin89	
Mar 2	22 58-68	Thetis	12.7	2.331	10.1	5 45.2 21 20	2.7 13 41 36	-50-36 -27-23 -2-29 105 102 94-	94-	94-	all	Goffin87	
Mar 5	6 19-19	Melete	12.6	2.545	10.4	19 48.8 -14 40 2.4 3	7 32 15 39	-32-26 20 -26 20 -9 19 48 79 79-	79-	79-	all	MPC12189	
Mar 6	9 58-60	Liguria	14.3	3.632	210241	8.1 K2	18 27.1 -31 0 6.3 5	132-27-116-37 -85-52 69 43 59-	59-	59-	all	MPC14160	
Mar 7	20 5-15	Pallas	6.7	1.240	17317	8.5 K0	12 47.3 -2 26 0.2 31	41 -73 31-11 -21 42 170 85	56-	56-	e 31E	Goffin87	
Mar 8	3 17-31	Syrtis	12.5	2.284	133528	9.0 F0	11 58.1 -4 51 3.6 12	-50-24-104 0 172 35 165 74	51-	51-	e125W	MPC14930	
Mar 11	13 58-85	Cunomia	9.7	1.941	10.7	8 18.6 11 59	0.4 70 70 10	91-41 53-36 0-36 134 169	20-	20-	none	Goffin87	







event. If a photographic magnitude has been used for the star (the case for source AGK3 or A.C. noted above in the discussion of  $m_p$  for stars), it will usually be brighter visually than the tabulated value (by a magnitude or more for reddish spectral-type K and M stars; no brighter for the less common bluish type O, B, and A stars), so that the actual  $\Delta m$  may be much larger than the given value. I plan to

correct this problem with a future star catalog update. A  $\Delta m$  value much less than 1.0 in general means that the event can be reliably observed only photoelectrically or with video equipment. The chances of seeing smaller  $\Delta m$ 's visually is increased if the star is relatively bright, or if a larger telescope is used to increase the apparent brightness of a faint star; variable star observers familiar

Table 2 Part B

1991	M I N O R	P L A N E T	Motion	S	T	A	R	M-n. Geocentric	Comparison Data	A P P A R E N T					
Date	No.	Name	km-Diam.	RA	Dec.	SAO No	DM/ID No	D	U. I.	ACK2 No	Shift	Time	R.A.	Dec.	
Mar 15	146	Lucina	140 0.11	552 C	0.176	308°5		7 <sup>h</sup> 55 <sup>m</sup> 4	3 <sup>h</sup> 26 <sup>m</sup> C				13 <sup>h</sup> 27 <sup>m</sup> 5	12°22'	
Mar 16	369	Aeria	52 9.04	182 M	0.199	288.8	+26°2149	1 17.7	3.60N A	N26°1145			10 55.7	25 49	
Mar 17	334	Chicago	170 0.06	1062 C	0.234	31.4	162723	2 45.7	0.10S UZ		0 <sup>h</sup> 23	-0 <sup>m</sup> 5	19 31.2	-19 24	
Mar 17	511	Davida	337 0.14	2129 C	0.404	63.3		11 44.9	2.04S C				2 43.8	5 1	
Mar 18	19	Fortuna	171 0.12	673 C	0.265	88.5	L 1 106	8 34.0	3.37N Hc		-1.31	0.8	6 7.0	21 38	
Mar 20	121	Hermione	217 0.09	1434 C	0.154	89.5		20 13.7	0.93N C				5 54.3	27 28	
Mar 24	532	Herculina	217 0.14	1021 S	0.215	77.6		14 27.3	1.98N C		0.10	2.5	15 12.4	-23 12	
Mar 24	594	Ecard	93 0.06	338 CP:	0.066	319.2	183265	17 7.3	0.23S UX				5 39.9	13 16	
Mar 24	360	Carlova	121 0.07	443 C	0.307	74.3	A1843076	23 9.0	2.62S C				15 12.7	19 14	
Mar 26	747	Winchester	178 0.10	1050 C	0.205	298.9	+20 2685	0 47.6	1.58S Ma	N19 1193	-0.16	0.1	12 7.5	19 16	
Mar 27	187	Lamberta	135 0.14	422 C	0.137	175.1	183474	14 20.3	7.04W UX		0.37	0.9	15 26.3	-22 29	
Mar 27	423	Piotina	217 0.11	1226 C	0.145	107.5	B2365574	21 40.9	2.26N C				17 41.0	-22 37	
Mar 28	9	Metis	190 0.16	759 S	0.161	115.6	79974	+27 1544	A 0 23.0	5.56S Ua	N27 387	0.28	0.1	8 8.3	27 30
Mar 28	9	Metis	190 0.16	759 S	0.161	115.6	79974	+27 1544	B 0 21.5	2.62S Ua	N27 857	0.28	0.1	8 8.3	27 30
Mar 28	30	Uranita	104 0.09	353 S	0.219	292.4	118734	+3 2475	17 4.0	2.29N UM	N 2 1470	-0.33	-0.2	11 13.5	2 19
Mar 30	2	Pallas	533 0.55	3638 B	0.368	349.0	113404	+7 2339	5 56.0	4.80E UM	N 6 1335	-0.20	0.0	10 37.9	6 32
Mar 31	96	Aegle	174 0.14	735 U	0.217	278.7	156875	-17 3465	23 52.9	1.00S S			11 45.4	-13 8	
Apr 1	46	Hestia	137 0.06	479 P	0.392	80.6	94021	+19 740	3 9.7	2.43N UR	N19 359	-0.03	0.0	4 35.2	19 57
Apr 2	624	Hektor	224 0.08	2351 J	0.123	270.0	131911	C2810228	21 13.5	0.33S PS		0.04	2.8	13 43.5	-26 36
Apr 3	360	Carlova	127 0.06	445 C	0.330	77.7	A1944403	12 29.4	1.99N C				5 52.4	19 0	
Apr 4	360	Carlova	127 0.06	445 C	0.332	78.0	A1944154	10 5.5	1.46N C				5 53.6	19 4	
Apr 4	56	Melete	117 0.07	325 P	0.529	71.2	164009	-10 5651	16 24.0	2.20S JIS		0.04	-0.7	20 56.4	-9 57
Apr 4	Venus	12220 13.70			1.191	71.8	93319	+18 424	13 38.5	7.39W UX	N18 241	3.35	0.0	3 16.2	13 43
Apr 5	17	Thetis	97 0.05	315 S	0.250	85.6	-1 344		1 13.1	1.78N Hc		-0.64	-0.1	6 13.4	22 18
Apr 5	16	PSYCHE	264 0.12	1559 M	0.315	83.6	77145	+20 944	19 58.3	0.03S UX	N20 502	-0.11	0.0	5 23.7	21 0
Apr 7	532	Herculina	217 0.13	1013 S	0.273	84.1	A2355505		1 48.5	0.61N C			6 45.2	27 51	
Apr 8	184	Dejopaja	56 0.03	215 J	0.181	99.7			1 58.5	1.01S C			7 13.7	22 44	
Apr 8	532	Herculina	217 0.13	1011 S	0.280	84.8			23 43.1	2.22N C			6 47.6	27 54	
Apr 9	48	Doris	219 0.10	1214 CG	0.290	83.8			18 39.5	0.58N C			5 56.9	17 29	
Apr 11	4	Vesta	560 0.25	4385 V	0.383	77.2	+19 734	3 23.1	1.23N MX	N20 415	-0.22	0.5	4 32.2	25 7	
Apr 11	16	Psyche	264 0.12	1563 M	0.327	84.7	A2141271	13 21.2	0.12N C				5 31.8	21 12	
Apr 12	451	Patientia	230 0.09	1280 CU	0.354	74.2	76692	+21 680	0 35.0	2.58S UR	N21 437	0.11	0.3	4 39.1	21 30
Apr 13	19	Fortuna	171 0.10	687 S	0.348	92.9	A2261565	19 5.6	2.26N C				6 42.3	21 32	
Apr 15	270	Anahita	52 0.04	99 S	0.380	76.9	L 5 972	10 43.4	4.23N H				19 45.4	-20 44	
Apr 16	375	Jusula	214 0.13	1288 C	0.193	270.5	205100	C32 9785	1 24.7	2.54N S			14 0.9	-33 17	
Apr 23	156	Xanthippe	126 0.07	438 C	0.320	61.3	144968	-10 5553	A 20 31.2	2.31N PU		0.57	0.1	20 56.4	-9 44
Apr 23	156	Xanthippe	126 0.07	436 C	0.320	61.3	144968	-10 5553	B 20 31.3	4.21N PU		0.67	0.1	20 56.4	-9 44
Apr 26	451	Patientia	230 0.09	1281 CU	0.370	77.2			1 57.6	1.97N C			5 0.4	22 45	
Apr 28	433	Eros	23 0.05	21 S	0.205	252.3	C4811360	A 10 15.8	5.58N G				16 59.8	-48 38	
Apr 28	433	Eros	23 0.05	21 S	0.205	252.3	C4811360	B 10 16.0	6.58N G				16 59.8	-48 38	
May 2	48	Doris	219 0.09	1216 CG	0.335	88.5		6 49.1	2.01S C				6 26.5	17 57	
May 2	19	Fortuna	171 0.09	696 G	0.383	96.1	79169	+21 1540	19 29.2	2.54N UM	N21 789	-0.21	-0.6	7 12.1	20 59
May 3	43	Doris	219 0.09	1216 CG	0.337	88.7	A1549104	3 53.5	2.07S C				6 28.1	17 58	
May 5	15	Eunomia	272 0.14	1630 S	0.224	104.0	98056	+10 1854	11 0.6	0.79S UM	N10 1131	-0.28	-0.8	8 41.7	10 28
May 5	Venus	12220 15.55			1.130	86.6	77437	+25 931	12 27.5	0.83N UX	N25 529	-0.03	-0.1	5 42.3	25 43
May 6	45	Eugenia	214 0.15	1936 FC	0.057	111.5			18 34.4	4.17N Xa	N11 1286	0.28	-4.3	11 5.6	11 21
May 7	15	Eunomia	272 0.14	1632 S	0.231	104.2			20 7.2	0.91N C			8 43.9	10 20	
May 9	Venus	12220 17.01			1.120	88.7	77838	+25 1073	4 0.8	5.75S UX	N25 508	0.02	0.0	6 0.5	25 54
May 10	27	Lutetia	115 0.08	359 S	0.343	108.9	+17 2069	7 7.3	1.09N Xa	N17 1920	0.25	-0.7	9 21.5	17 12	

with estimating small magnitude differences may also have some advantage with small magnitude drops. Good atmospheric seeing (low scintillation) and bluer stars (to produce a color change, since asteroids are mainly orangish in color, like a spectral type K star) also help.  $\Delta m$ 's of 0.4 and smaller have been

detected visually, but usually with unacceptably long reaction times.

Explanation of data in Table 2: The date, occulting object's name, and the star's SAO number are repeated for identification. The minor planet's number, the

Table 1 part C

1991 Universal Date	P L A Name	N E T $\Delta A$	S $\Delta A$	Sp	A R R.A. (1950) Dec.	Occultation $\Delta m$ dur. df. P	Possible Path LolLal LonLam Loelae	El	M O N	Up	Source	
May 11 13 46-47 <sup>11</sup>	Thetis	13.3 3.176	10.3	6 <sup>h</sup> 58 <sup>m</sup> 4	22°26'	3.0 3 <sup>5</sup>	138°39'138°39'157°31°	54°	91°	10-	Goffin87	
May 13 12 46-47	Fortuna	12.1 2.801	11.7	7 27.3	20 34	1.0 5	120-16 120-16 138-23	59	69	1-	MPC13923	
May 15 4 32-33	Pandora	12.5 2.782	146879	9.2 G5	23 42.1	3.3 2	10 59	-25-12 13 -7	50 74	2+	MPC15524	
May 13 20 14	Nemusa	12.7 3.405	110447	8.8 G0	2 14.2	9 33	4.0 3	8 36	9 0 141-29	23 86	28+	Goffin87
May 21 1 38	Doris	12.6 3.567	11.7	6 51.6	17 58	1.3 6	10 24	-77 34 -49 0 -77 34	44 50	53+	MPC12188	
May 22 10 59-61	Eunomia	10.9 2.965	10.9	8 56.1	9 33	0.7 11	14 16	119 2 128 0 157 -9	74 37	67+	Goffin87	
May 27 3 7-19	Rachella	12.2 2.371	134425	7.3 B9	16 26.9	-25 12	4.9 7	20 34	19 30 -45 9-114 23	175 19	98+	w 14E
May 27 4 51-70	Anahita	11.6 1.278	10.1	20 32.8	-17 12	1.7 7	31 36	-82-18 -42-17 0 0	119 76	98+	w 0E	
May 30 11 3-6	Dunham	18.3 2.765	9.6	10 6.1	13 16	8.7 1	17309	131 32 148 23 173 13	81 121	96-	e140E	
Jun 1 3 40	Hylaea	11.7 4.253	92866	9.0 K0	2 14.2	16 40	2.8 11	10 14 France, UK (low,dawn)	33 107	88-	Goffin86	
Jun 3 7 18	Venus	-4.2 0.793	79847	6.8 K0	7 56.7	23 19	498	7 1 Yukon, se AK, HI's	45 161	72-	NAO001	
Jun 3 8 9-16	Phocaea	10.6 1.232	106792	6.9 M0	21 0.4	15 46	3.7 5	14 24 -119-40 -88-12 -63 29	106 30	72-	MPC12183	
Jun 3 8 27	Carina	13.7 3.399	11.7	7 27.1	20 35	2.2 3	9 41	156-16 1 0 156-16	39 155	72-	MPC14754	
Jun 5 21 33-34	Chiron	15.611.087	9.6 F5	7 40.7	14 52	6.0 6	21 80	-47-18 -47-18 -38-21	41 128	48-	MarSDN88	
Jun 9 10 55-67	Lucina	12.4 2.066	12.0	12 40.8	10 19	1.0 13	26 21	153 46 161 13-168-26	107 145	13-	MPC15384	
Jun 10 21 46-54	Hebe	9.6 1.683	146041	7.5 A2	22 18.8	-6 30	2.2 14	20 13 31 18 60 15 105 16	105 82	4-	e 88E	
Jun 11/6 20-21	Jupiter	-1.9 5.916	98207	7.8 G5	8 51.1	18 25	2270	15 2 OR to se AK, HI, NZ	51 58	2-	NAO001	
Jun 11 11 34-42	Ekard	13.1 1.845	158489	4.5 A2	14 16.4	-13 8	8.6 11	32 29 Antarctica'n	137 151	2-	EMP 1985	
Jun 11 14 9-26	Eros	11.5 0.549	226005	8.0 K2	15 34.8	-41 24	3.6 3	20 41 -152-14 163-12 133 33	152 161	1-	EMP 1985	
Jun 13 12 20-36	Diogenes	11.4 1.949	185272	8.2 A3	17 16.9	-26 34	3.3 17	22 13 -108 1-175-28 81-18 176 164	2+	w 91E	MPC12305	
Jun 13 21 3-7	Hebe	9.5 1.644	145071	9.3 F8	22 21.7	-6 28	0.9 15	2 13 53 41 71 40 98 39	107 126	3+	Goffin86	
Jun 15 4 4-17	Ligura	13.1 2.366	210543	7.9 K0	18 42.6	-34 38	5.3 10	22 25 31-27 -37-56-146-31	160 155	10+	w128W	
Jun 16 5 15-38	Elektra	11.7 2.175	143734	8.7 A0	13 41.1	-0 6	3.1 23	35 17 3 -1 -58-11-132-20	141 154	19+	MPC14160	
Jun 16 9 31-42	Phocaea	10.4 1.145	9.6 A2	21 10.5	20 12	1.2 6	17 23	-144-41-119-10-100-44	112 147	21+	MPC14159	
Jun 17 13 2-3	Dunham	18.5 2.997	11.4	10 24.3	11 31	7.1 0	13334	84-22 93-26 113-34	68 5	32+	EMP 1986	
Jun 19 8 38	Venus	-4.3 0.683	98329	8.4 G5	9 1.0	18 53	666	9 1 eastern Australia	45 48	52+	NAO001	
Jun 19 17 21-35	Berbericia	12.4 2.303	159636	9.2 K0	15 58.5	-15 28	3.3 14	23 18 153 -4 96-25 3-35 153 57	56+	w106E	EMP 1986	
Jun 20 9 18	Cybele	13.3 4.282	93133	8.1 F5	2 47.5	13 30	5.3 6	11 27 -90 19 -90 19 -73 25	44 148	63+	MPC12302	
Jun 25 4 10-30	Kalypso	13.8 2.249	164279	6.2 A0	21 14.5	-13 29	7.7 21	53 27 Antarctica'n, S.Af.?2'n	136 66	97+	MPC12188	
Jun 25 13 31-46	Hedwig	11.8 1.460	185342	9.1 A3	17 20.0	-29 29	2.8 12	23 18 -144 1 166 0 109 38	167 5	98+	EMP 1989	
Jun 26 3 59-62	Daphne	13.5 3.288	199714	8.9 K2	1 8.0	6 29	4.6 9	17 26 -30-32 -9-29 28-21	75 115	99+	MPC13294	
Jun 29 8 55	Cybele	13.3 4.193	10.7 F5	2 57.1	14 7	2.7 7	12 26	-85 28 -85 28 -77 31	51 105	96-	MPC12302	
Jul 1 21 58	Virginia	13.2 2.152	92933	8.7 K0	2 22.2	13 25	4.5 2	8 35 56 46 56 46 68 51	61 66	80-	Landgraf	
Jul 1 31 37-46	Melete	11.6 1.448	11.1 K2	23 8.8	4 11	1.0 12	25 18	-13-47 19-35 53-18	109 17	79-	MPC12189	
Jul 3 1 0-14	Elektra	11.5 2.046	143525	8.4 B9	19 30.6	-0 55	3.1 15	23 16 128 0 79-21 0-27 146	52 71-	e 42W	MPC14159	
Jul 4 20 21-41	Kalypso	13.6 2.153	164223	9.1 F0	21 10.5	-13 54	4.5 14	33 26 9-29 -82-53 155	52 53-	e 46E	MPC12188	
Jul 7 5 15	Massalia	12.2 2.891	76609	7.4 F8	4 23.3	21 21	4.9 3	8 28 western S. Africa'n	36 27	28-	MPC11982	
Jul 9 7 26-44	Ate	13.1 1.883	163925	9.1 A3	20 48.0	-18 25	4.0 13	26 20 -32-15 -97-29-176-20	157 122	9-	e 52W	
Jul 9 22 31-61	Eros	12.4 0.841	206699	9.7 G5	15 26.3	-32 59	2.8 4	28 53 -135-77 -28-35 -1 38	129 155	5-	EMP 1985	
Jul 11 18 19	Jupiter	-1.8 6.223	98472	8.8 F8	9 14.6	16 46	1820	13 2 Balkans, cen, Africa	28 28	0-	NAO001	
Jul 12 7 31-42	Ligura	13.1 2.336	9.8 F0	13 15.4	-34 49	3.4 10	22 25	-27-43 -90-68 150-46	161 154	0+	MPC14160	
Jul 13 8 4-39	Anahita	10.4	20 29.7	10 16	11 27	2.8 13	0.8 9	35 26 -46 5-108 -5 178 1	164 174	4+	MPC16844	
Jul 15 14 33-42	Tercidina	12.8 1.867	10.1 G0	0 10.6	11 27	2.8 13	26 27	154-32-177-17-145	3 105	157 20+	MPC13442	
Jul 23 3 54-57	Ceres	8.7 2.555	11.5	13 47.0	-4 45	0.07 43	16 4	10378 -114 33-101 21 -76 13	97 54	89+	MPC12187	
Jul 23 6 51	Dunham	18.6 3.387	11.6	11 7.9	7 5	7.0 0	10378	-168 19-168 19-160 17	46 96	89+	EMP 1986	
Jul 23 22-23	Interamnia	11.8 3.406	12.0	5 6.9	31 18	0.6 9	9 15	76 3 76 3 85 8	42 167	93+	Schmadel	
Jul 24 13 43	Massalia	12.2 2.746	76932	9.1 A0	5 0.9	22 28	3.2 4	8 26 -156 14-156 14-138 21	44 160	96+	w147W	
Jul 25 10 16	Mercury	0.5 0.857	98923	8.9 G0	10 0.7	11 0	198	7 1 126 1 -39 0 126 1	27 138	98+	MPC11982	
Jul 27 13 4	Arethusa	13.1 3.238	76893	8.2 A0	4 58.1	23 22	5.0 4	9 32 170-39 170-39-175-34	48 121	99-	DE130	

expected diameter in kilometers (km), and the apparent angular diameter in arc seconds ("), are given. For the source of diameters of asteroids, see the discussion of occultation duration above. Under RSOI, "Radius of Sphere Of Influence," the distance in km from the object is given where its gravitational attraction is equal to that of the Sun, assuming (pessimistically) that the mean density of the object is twice that of the Sun. Satellites are possible

for much greater distances, since tidal or differential forces determine satellite capture; according to the theory of three-body motion, these forces are proportional to the cube of the ratio of the distances, not the square. Very few secondary extinctions have actually been reported at distances greater than RSOI. The cube ratio usually gives a distance about 100 times the asteroid's diameter, which is usually larger than the Earth's diameter. For major planets,

Table 2 part C

1991 Date	M I N O R Name	P L A N E T km-Diam. - RSOI	Type	Motion °/Day	S T A SAO No DM/10 No	R D	Min. U. I.	Geocentric Sep.	Comparison Data AGK3 No	Shift	Time	A P P A R E N T R.A. Dec.
May 11	17 Thetis	93 0.04	313 S	0.343	92°9	L 1 2237	10°44.1	1°34N H			7 <sup>h</sup> 0 <sup>m</sup> 9	22°22'
May 13	19 Fortuna	171 0.08	702 G	0.398	97.9	A21°56424	10 43.9	1.36S C			7 29.8	20 29
May 15	55 Pandora	68 0.03	176 M	0.408	65.2	146879 - 6 6275	4 34.7	0.70N UX		-0°20	23 44.2	-5 56
May 18	51 Nemausa	137 0.06	517 CU	0.442	74.8	110447 + 9 296	20 15.8	0.75S Za N 9°	218	-0.18	2 16.4	9 45
May 21	48 Boris	219 0.08	1219 CG	0.360	92.2		1 35.8	1.30N C			6 54.0	17 55
May 22	15 Eunomia	272 0.13	1647 S	0.273	105.6		10 57.3	0.09N C			8 58.4	9 23
May 27	674 Rachelia	101 0.06	442 S	0.214	265.6	C2412694	3 12.9	2.09N YG		-1.78	1.5	16 29.5
May 27	270 Anahita	52 0.06	95 S	0.185	65.3	L 5 4030	5 5.1	1.21N H			20 35.2	-17 3
May 30	3123 Dunham	13 0.01	17 F	0.237	111.2		11 1.5	1.58N C			10 8.3	13 3
Jun 1	16 Psyche	429 0.14	3944 C	0.309	70.1	92866 +16 265	3 40.9	1.88N UX	N16 207	0.10	-0.4	2 16.5
Jun 3	25 Phocaea	73 0.08	144 S	0.103	102.7	79847 +23 1863	7 18.2	1.67N UR	N23 901	-0.16	0.0	7 59.2
Jun 3	360 Carola	121 0.05	450 C	0.406	93.1		8 15.3	1.27N MR	N15 2333	0.00	0.3	21 2.4
Jun 5	2060 Citron	200 0.02	3767 B	0.095	96.3	A2156413	8 25.3	0.96S C			7 29.6	20 30
Jun 9	146 Lucina	140 0.09	546 C	0.178	154.3	L 4 2389	21 30.6	0.29S H			7 43.1	14 46
Jun 12	6 Hebe	186 0.15	711 S	0.254	86.5		21 53.6	2.01N UZ		-0.27	0.0	22 21.0
Jun 11	Jupiter	140904 32.84		0.174	105.9	146041 - 6 5972	6 19.1	14.26S UX	N18 917	0.07	0.7	8 53.5
Jun 11	694 Icarid	93 0.07	309 CP:	0.151	322.0	98207 +18 2076	11 41.3	5.77S F		-0.10	0.1	14 18.7
Jun 11	433 Freya	23 0.05	23 S	0.401	325.4	158489 -12 4018	11 14.7	9.74N PS		-0.47	0.1	15 37.6
Jun 11	423 Dido	217 0.15	1220 C	0.213	258.5	226005 P41 7277	12 28.0	0.37S UX		0.34	-0.2	17 19.5
Jun 13	6 Hebe	186 0.15	709 S	0.242	88.5	146071 - 6 5984	21 9.3	3.81N UX		-0.04	1.2	22 23.9
Jun 15	355 Ligura	135 0.08	675 C	0.192	260.6	210543 C3413087	4 9.8	1.40S PS		-0.81	1.0	18 45.4
Jun 15	130 Elektra	189 0.12	1016 G	0.125	259.3	143734 - 0 3830	5 25.2	0.70S Ma	S 0 2522	0.60	2.2	19 43.3
Jun 16	25 Phocaea	73 0.09	144 S	0.352	23.2	+19 4648	9 39.5	2.02N Ma	N20 2387	-0.53	-0.1	21 12.4
Jun 17	3123 Dunham	13 0.01	17 F	0.289	111.8		12 59.7	0.98S C			10 26.5	11 18
Jun 19	Venus	12220 25.41		0.916	110.8	98329 +19 2147	8 38.1	12.95S UX	N18 933	0.15	0.0	9 3.4
Jun 19	776 Barbentia	184 0.11	1042 C	0.189	255.9	159636 -15 4232	17 28.6	1.07S UX		-0.61	-1.0	16 0.9
Jun 20	65 Cybele	230 0.07	1630 P	0.275	75.0	93133 +13 456	9 20.4	1.11N UX	N13 226	-0.31	0.7	2 49.7
Jun 25	53 Kallipso	119 0.07	511 XC	0.082	246.5	164279 +13 5897	4 18.8	4.02S UZ		-0.03	-2.4	21 16.8
Jun 25	476 Hedwig	121 0.11	422 P	0.232	296.4	183342 C2913461	13 38.5	3.56N XY		-1.22	1.8	17 22.7
Jun 26	41 Daphne	182 0.08	1008 C	0.207	79.9	109714 + 5 150	4 4.1	1.11S UX	N 6 115	0.25	0.1	1 10.1
Jun 29	65 Cybele	230 0.08	1633 P	0.261	76.0	+3 488	8 56.9	1.31N MX	N14 268	-0.70	0.0	2 59.4
Jul 1	50 Virginia	88 0.06	201 X	0.552	73.4	92933 +12 326	21 59.6	3.58N Xa	N13 195	0.06	0.0	2 24.5
Jul 2	56 Melite	117 0.11	330 P	0.219	63.6	+3 4832	1 46.3	2.60S Ma	N 4 3122	-0.21	-0.6	23 11.0
Jul 3	130 Elektra	189 0.13	1004 G	0.200	247.0	-1 3769	1 6.9	2.21S MP	S 0 2485	-0.76	-0.7	19 32.8
Jul 4	53 Kallipso	119 0.08	510 XC	0.135	247.8	164223 -14 5963	20 28.3	0.29S UX		-0.43	-1.0	21 12.8
Jul 7	20 Massalia	151 0.07	516 S	0.509	81.2	76609 +21 644	5 16.3	2.84S Ua	N21 419	-0.37	-0.1	4 25.8
Jul 9	111 Ate	139 0.10	602 C	0.183	261.8	163925 -18 5790	7 34.0	0.86S UX		0.15	-0.2	20 50.4
Jul 9	433 Eros	23 0.04	24 S	0.253	22.6	206699 C3210831	22 45.0	1.34S S			15 28.9	-33 8
Jul 11	Jupiter	140904 31.22		0.206	107.4	98472 +17 2052	18 17.0	8.49S UX	N16 997	0.10	-0.1	9 16.9
Jul 12	356 Ligura	135 0.08	669 C	0.199	275.1	C3412693	7 37.1	2.16S H			18 18.2	-34 48
Jul 13	270 Anahita	52 0.08	93 S	0.197	266.5	L 5 3891	8 20.6	1.72N H			20 32.0	-15 22
Jul 15	345 Teretina	100 0.07	302 C	0.181	59.3	+10 16	14 42.3	0.77S A	N11 15		0 12.8	11 41
Jul 23	1 Cerus	946 0.51	10138 G	0.253	126.1	L 2 3446	3 53.7	2.62N H			13 49.2	-4 57
Jul 23	3123 Dunham	13 0.01	17 F	0.356	113.0		6 48.9	1.58N C			11 10.1	6 51
Jul 23	704 Interamnia	333 0.13	2144 F	0.378	88.3		23 25.0	0.29S C			5 9.6	31 21
Jul 24	20 Massalia	151 0.08	511 S	0.503	84.8	76932 +22 812	13 45.2	0.90N UX	N22 492	0.04	-0.1	5 3.4
Jul 25	Mercury	4880 7.85	20375	0.952	122.3	98923 +11 2153	10 12.3	4.95N UX	N10 1291	0.24	0.0	10 2.9
Jul 27	95 Arethusa	145 0.06	599 C	0.384	90.5	76893 +23 796	18 5.2	2.14S UR	N23 458	-0.17	-0.1	5 0.6

no value is listed under the RSOI column, since it is always greater than 99999 km.

After RSOI, the taxonomic Type is given for asteroids, as specified in pages 1139 - 1150 of Asteroids II, using the types given by David Tholen in his 1984 Ph.D. dissertation and amended by him for the book. Most of the old classes mentioned in QN 4 (1), 7 have been retained, but several new classes are defined. A brief description of most of the classes is given below:

- ```

B C subclass, mainly members of Themis family
C carbonaceous, low albedo, most common outer belt
D dark (very low albedo), common for Trojans
E enstatite achondrites, high albedo
F flat spectrum, C subclass, mainly Nysa family
G C subclass, includes Ceres
I inconsistent data, can't classify
M metallic, moderate albedo
P pseudo-M, low albedo, spectra like M
Q Apollo (almost unique spectrum)
S silicate, moderate albedo, most common in the
  inner asteroid belt
T transition between S and D; not real sub class?
V Vesta (almost unique spectrum)
X E or M or P (current data can't distinguish;
  these have similar spectra, and differ only in
  albedo)

```

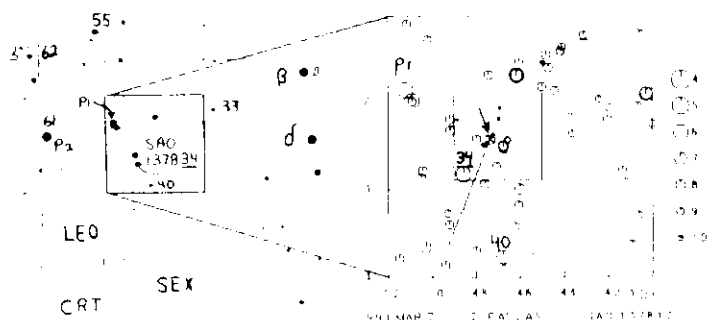
Tholen notes that his spectral/albedo "cluster analysis" defines 7 major classes: A (no special description), C, D, E, M, P, and S. In some cases, an asteroid's characteristics place it in an area between 2 or 3 of these classes, in which case each of the applicable class letters are used. Besides the other subclass and special types given above, Tholen also uses the following suffixes:

- ```

U    unusual spectrum, far from class cluster
    center
:    noisy data
::   very noisy data
---  data too noisy to permit classification.

```

The first value under Motion is the geocentric angular velocity of the occulting object in degrees/day. Multiply it by 2.5 to obtain the angular rate in seconds of arc per minute, which is useful for estimating when the asteroid's and star's images will merge, and how long it will be before they can be separated again. Normally, a separation of two or more seconds of arc will be needed to resolve the objects clearly. The position angle of the occulting object's motion is given under P.A.



The star's Bonner Durchmusterung (BD) or Cordoba Durchmusterung (CD) declination zone and catalog numbers are given under the DM/id No column, when available. The first character of the zone column identifies the catalog:

character identification

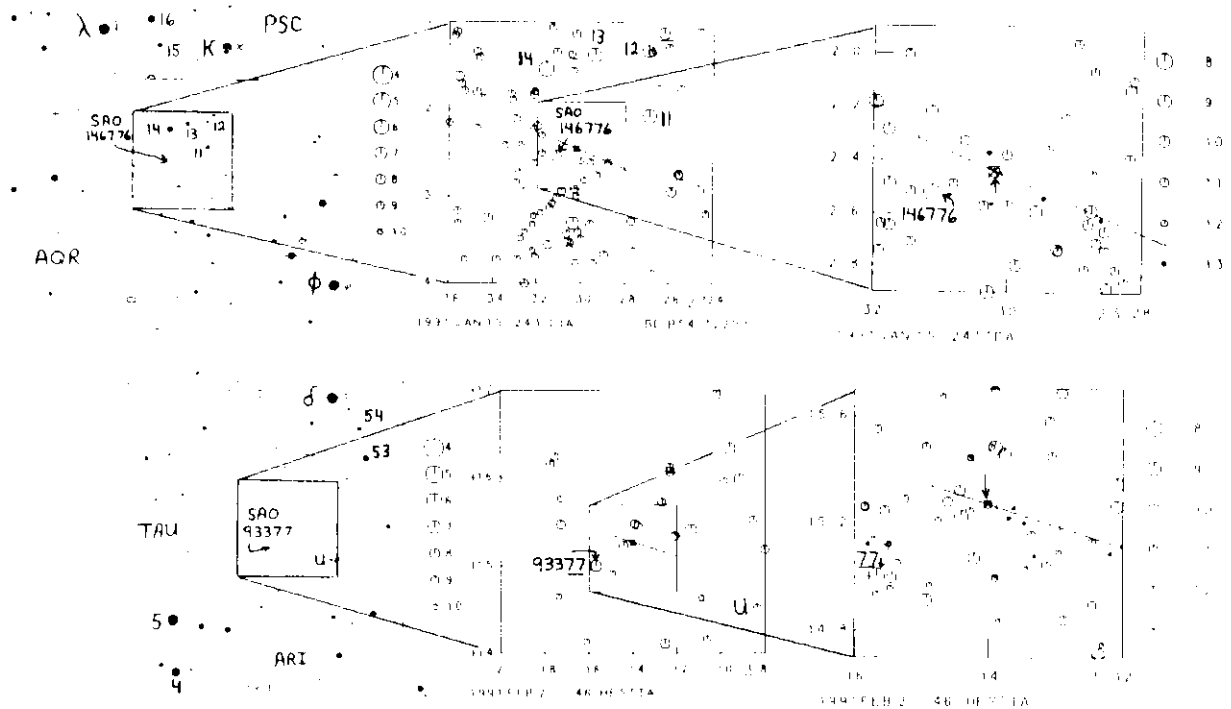
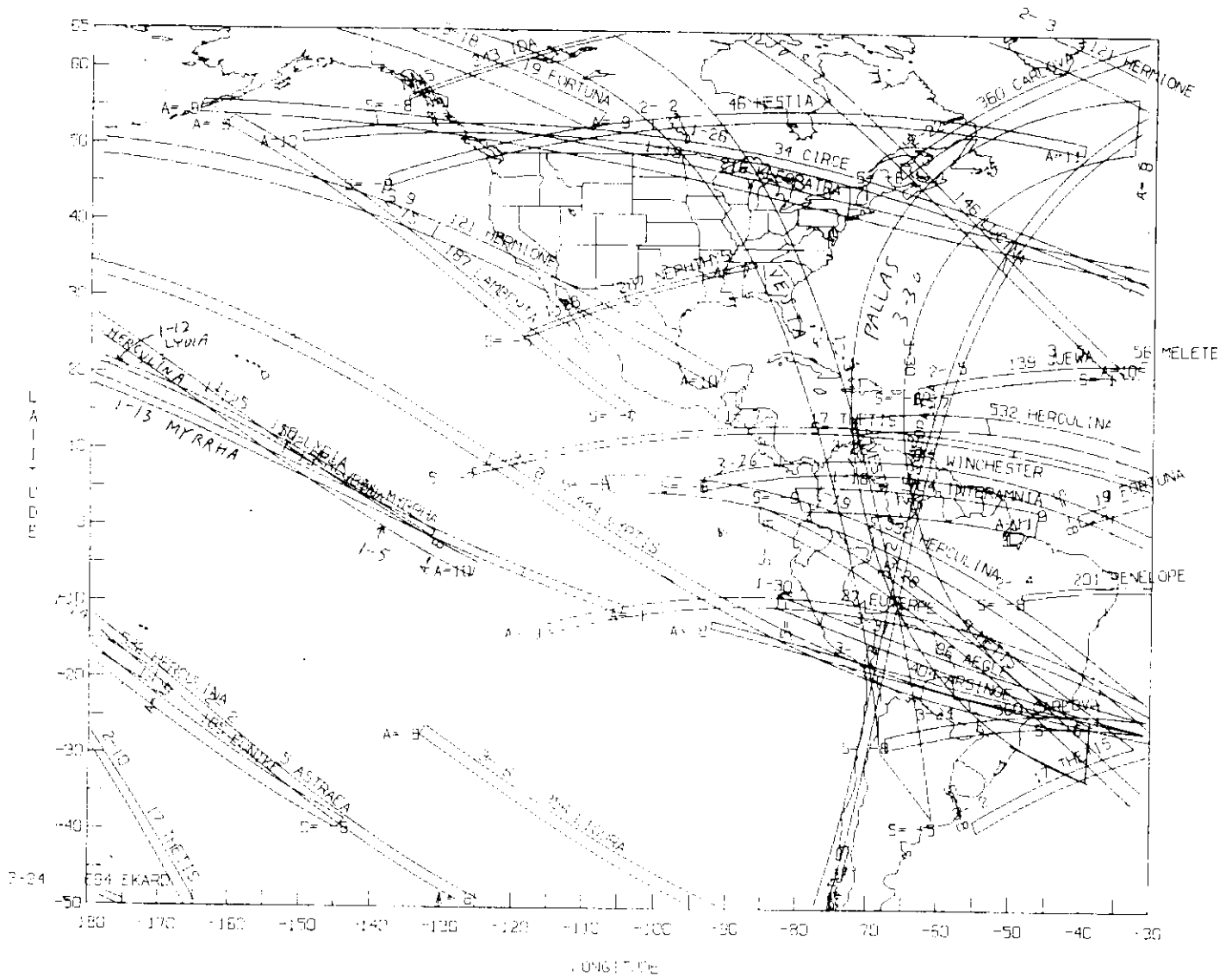
- ```

+ BD (Bonner Durchmusterung)
- BD (usually the southern part,
  sometimes called S.D.)
C CD (Cordoba Durchmusterung; -)
P Cape Photographic Durchmusterung (-)
L Lick Voyager catalogs; the five Lick
  "zones" are given below; the number
  within the zone is sequential in
  1950 R.A.
L 1 Lick Jupiter, or LJ (Gemini, Cancer)
L 2 Lick Saturn, or LS (Leo, Virgo)
L 3 Lick Uranus pre-encounter, or LU (Sgr)
L 4 Lick Uranus post-encounter, or LV (Gem)
L 5 Lick Neptune, or LN (Capricornus)
A Northern Astrographic Catalog (AC, +)
  The first 2 digits are usually the
  R.A.-sequential plate no. in the zone,
  while the last 3 are the number on
  the plate.
B Southern AC (- zones); the number is
  usually sequential throughout the
  zone, approximately by R.A.
Q Measured from a Palomar Schmidt plate
  (only a few in Scorpius)

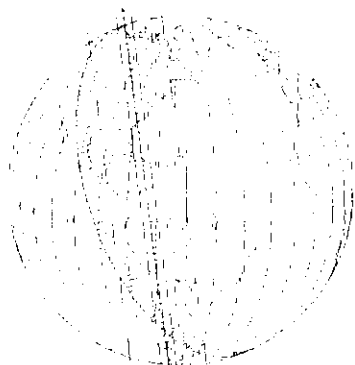
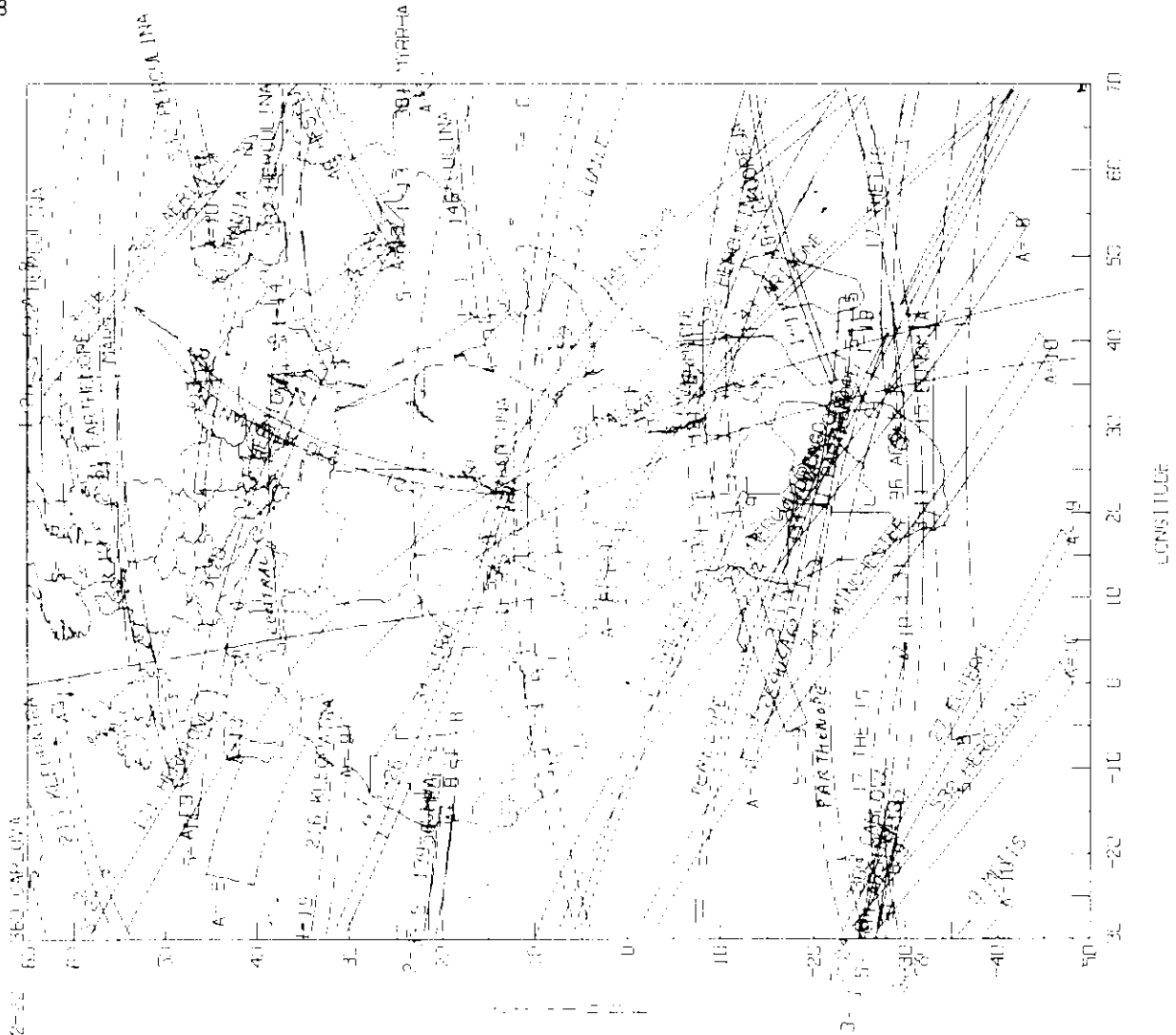
```

Following the star's numbers is the column D, the star's double star code. If separate predictions are given for the two components, "A" and "B" are used, "A" indicating the brighter component. Otherwise, the code is the same as that used for lunar occultation predictions as described in "Notice to Observers" dated 30 September 1976 distributed by Mrs. Marie Lukac; U.S. Naval Observatory (USNO); Washington, DC 20392-5100; U.S.A. For double stars, component magnitudes, separation and PA, and expected magnitude drops (when calculable) are given in notes about individual events at the end of this article. It is important to note that exceedingly accurate information about double stars can be gleaned from asteroidal occultations - more than an order of magnitude better than from lunar occultations, due to the slower apparent angular motion of the occulting body with respect to the star, especially with the widely ranging PA's of occultation that will be seen by observers separated by even a few km. Asteroidal occultations provide especially good opportunities to resolve spectroscopic binaries.

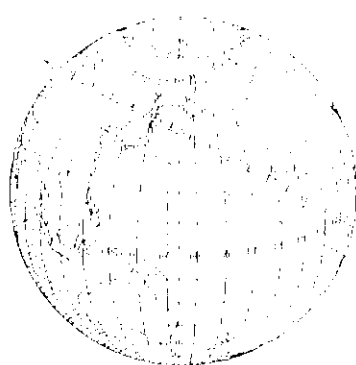
The geocentric Universal Time and distance of closest approach of the center of the planet to the star are given under the columns Min. Geocentric U., T., and Sep. Following the separation value is a letter indicating its direction, usually (N)orth or (S)outh. But when the motion is nearly due north-south, with the motion in declination four or more times that in right ascension, the direction is given as (E)ast or (W)est. These quantities, along with the position angle of the object's motion and its distance from the Earth " $\Delta AU$ " from Table 1, can be used with a linear approximation of the motion to calculate the path of the occultation on the Earth's surface, or



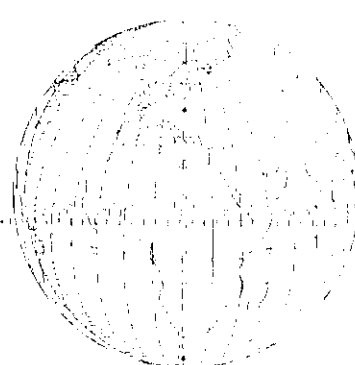
PLANETARY OCCULTATIONS, 1991 JAN. MAR.



SAO 93228 by Vesta 1991 Jan 3-4



Anonymous by Herculina 91 Jan 5



A21°44803 by Fortuna 1991 Jan 9





the time and distance of closest approach for a specified station. Leif Kristensen, Institute of Physics, Aarhus University, Aarhus C, DK 8000 Denmark can provide a program to do these calculations with a Texas Instruments hand calculator. Readers with some familiarity with astronomical computations can figure out how to do this from discussions of occultation calculations in books such as Jean Meeus' Astronomical Tables of the Sun, Moon, and Planets (Willmann-Bell, 1983); the Explanatory Supplement to the American Ephemeris and Nautical Almanac; or Isao Sato's "Catalog of 3539 Zodiacal Stars for the Equinox J2000.0" described in ON 4, No. 5 (although he uses standard notation in his formulae, the discussion is in Japanese). A useful PC project would be to program the use of these quantities to produce paths or local circumstances, and distribute this software to the many other IOTA PC users. Then, they could quickly update paths or compute new local circumstances when an update is obtained from "last-minute" astrometry, which would be especially useful if a detailed regional map or IOTA local circumstance prediction is not available.

Remainder of Article will appear in next ON: There is not time to complete this article before we must take it to the printers. So further explanation and documentation of my 1991 prediction, will appear in the next issue. This issue contains tabular data well into July, while the graphics cover at least the first third of the year. The tables for the rest of 1991 will be published next time. Table 3 giving stellar angular diameter data for all favorable 1991 events is in this issue, but its explanation will be in the next issue. It was also explained in the article on the predictions for 1991 in ON 4 (14), p. 341-352. The documentation of 1991 events will be similar to that for 1990 events in that article.

Finder charts and Soma's world maps are given here only for events that are not in Edwin Goffin's coverage. Soma's maps are also shown for some double stars. David Werner assembled and annotated my computer-generated charts, and compared them with TVMA.

#### Notes about Individual Events:

Jan. 3-4, (4) Vesta: See p. 28 for special article.

Jan. 13: See p. 7 and 8 of the last ON, and p. 31.

Jan. 14 (and 17 and 26): (532) Herculina may have a 45-km satellite from 1978 occultation data.

Jan. 15: Galileo may fly by (243) Ida, perhaps the 2nd ever encounter of a spacecraft with an asteroid. So any observations of occultations by Ida would be very valuable.

Jan. 19, (216) Kleopatra: See p. 28.

Jan. 19, (17) Thetis: The star is ZC 895, a spectroscopic binary with 6.1 and 8.3-mag. components separated by perhaps 0".0005.

Feb. 2, (5) Astraea: The star is ZC 1038, a spectroscopic binary.

Feb. 21: Mars will be 90% sunlit with a defect of

illumination of 0".84. The star will disappear against the narrow dark crescent.

Mar. 2, (216) Kleopatra: See p. 28.

Mar. 28, (9) Metis: The star is 11 Cancr = ADS 6612; predictions for both components are given. The secondary is 3" from the primary in p.a. 217°, so it should be possible to separate the stars. However, since the primary is so much brighter than the secondary, observation of an occultation of the secondary star will be very difficult.

April 1: (146) Hestia has a lightcurve resembling an eclipsing variable, and is one of the most accessible (by spacecraft) of the main-belt asteroids.

April 2: (624) Hektor, the largest Trojan asteroid, has strong evidence for being a contact binary, so like Kleopatra, occultation data could reveal a dumbbell shape.

April 4, Venus: Disappearance will be on the dark side of Venus' 79% sunlit disk.

Apr. 11, (4) Vesta: The small mag. drop will be hard to detect visually, but not impossible in a moderately large telescope if the seeing is very good.

Apr. 23: The star is ADS 14449, with separation 1".9 in p.a. 150°, so separate predictions are given for the two components. The occultation of the faint secondary star will be virtually impossible to detect, even if the path really is on Earth's surface.

Apr. 28: Separate predictions are given for the members of this binary (See 316), separated by 1" in p.a. 170°. With this separation, the stars will be merged unless the seeing is unusually good. Hence, if the primary is occulted, the secondary will remain visible, and the apparent mag. change will be 1.4, not 5 as given in the table. If the secondary is occulted, the apparent mag. drop will be only 0.3.

May 5 and 9, Venus: Disappearance will be on the dark side of Venus' 68% sunlit disk.

May 18: The star is ZC 334.

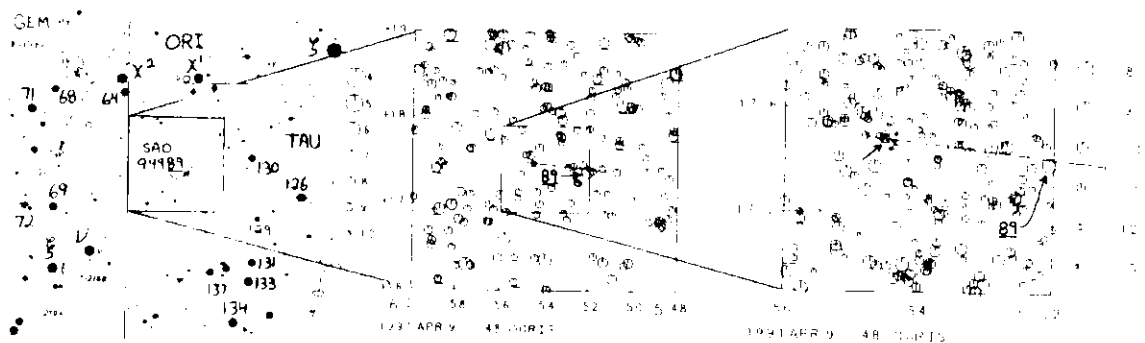
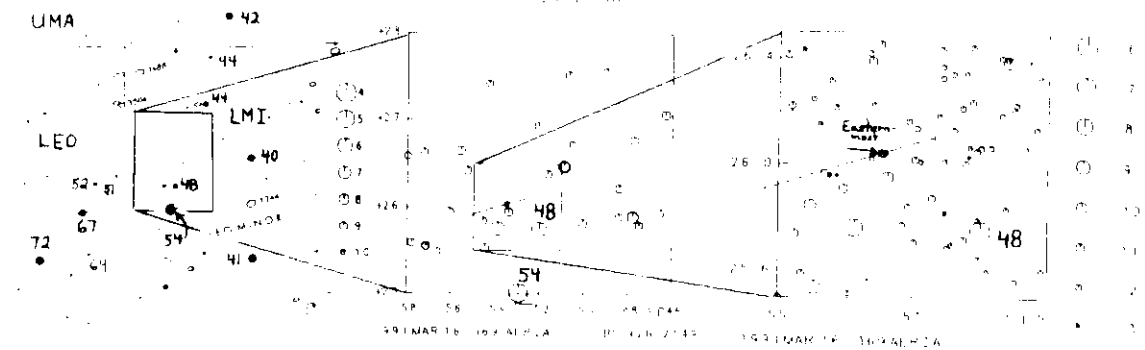
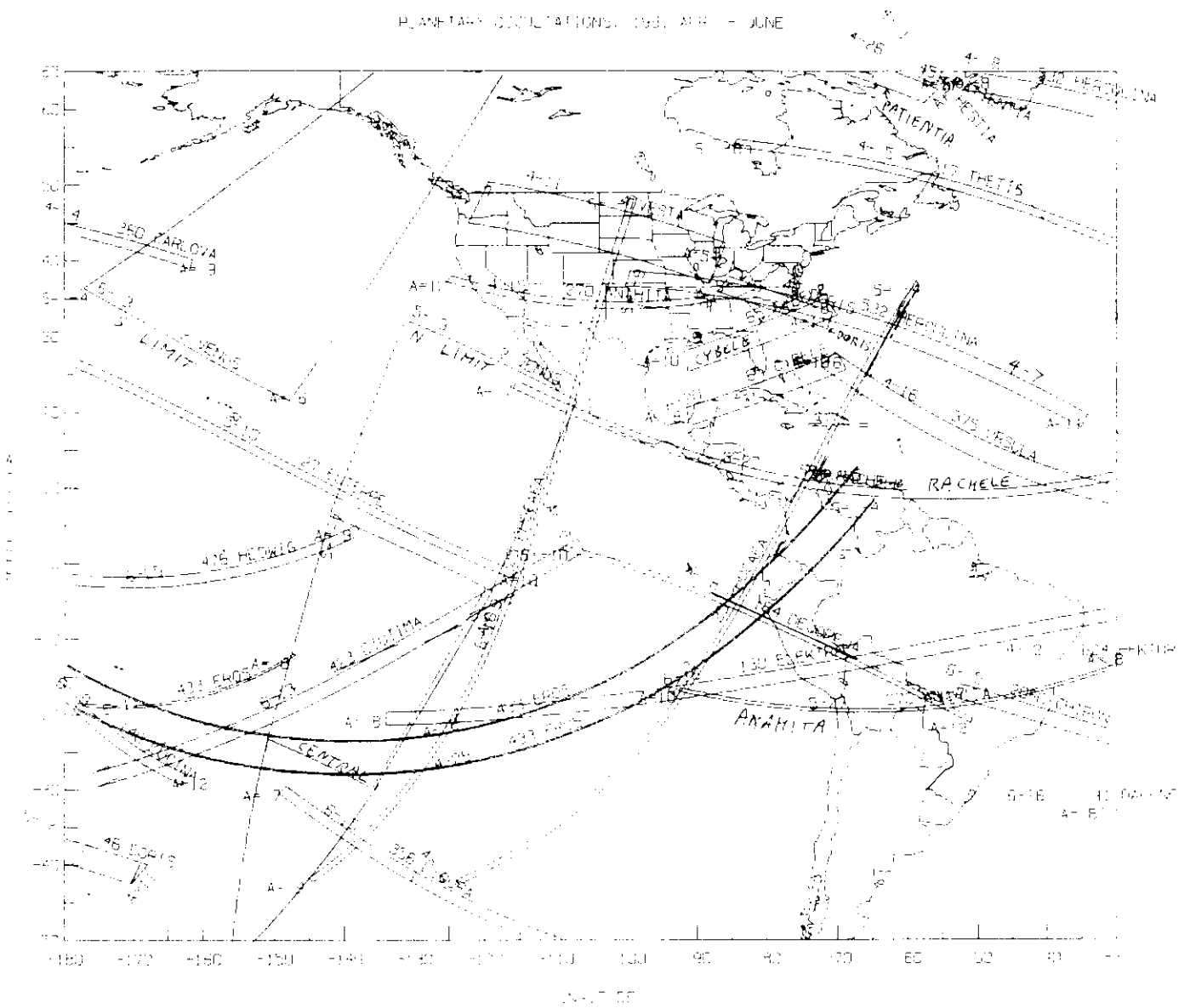
May 27, (674) Rachele: There was an error in the Yale proper motion in my combined catalog, corrected here. However, Goffin used the same catalog, and derived an incorrect path much farther south. Hence, Stamm sent data for the event to observers in S. America and southern Africa, but it might be visible from North America or even part of Europe. So Werner has annotated Goffin's finder charts, which are published in this issue.

June 3, Venus: Venus will be 55% sunlit.

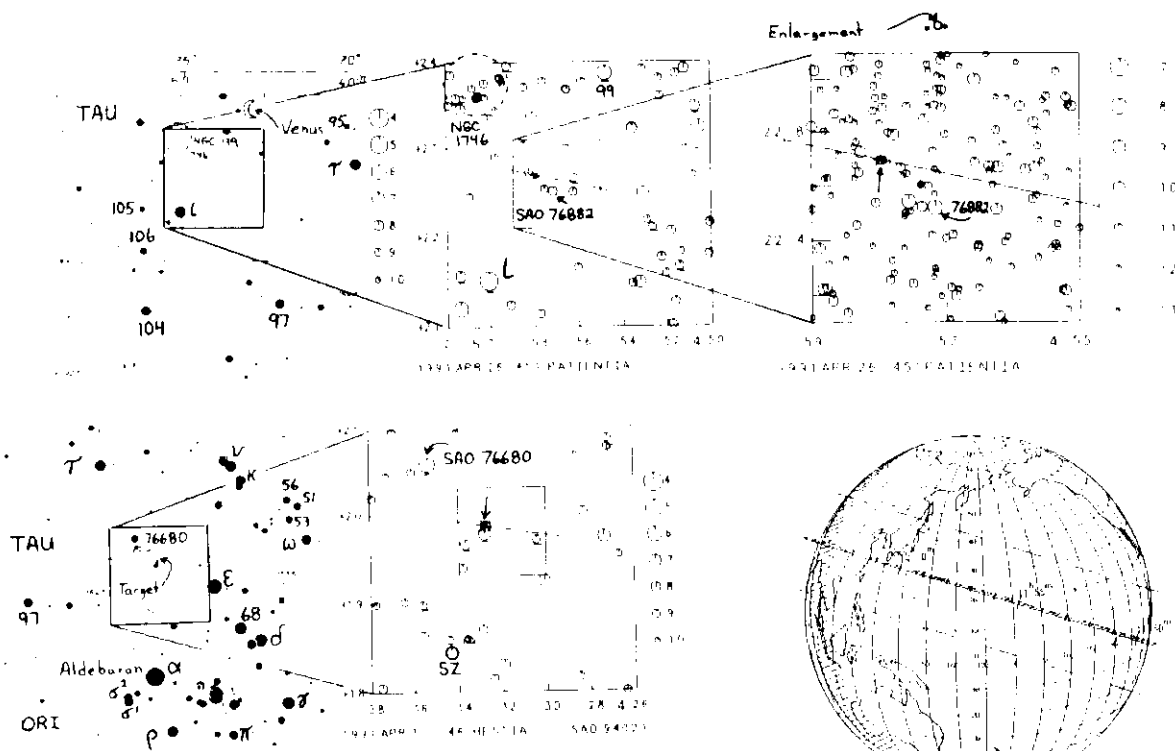
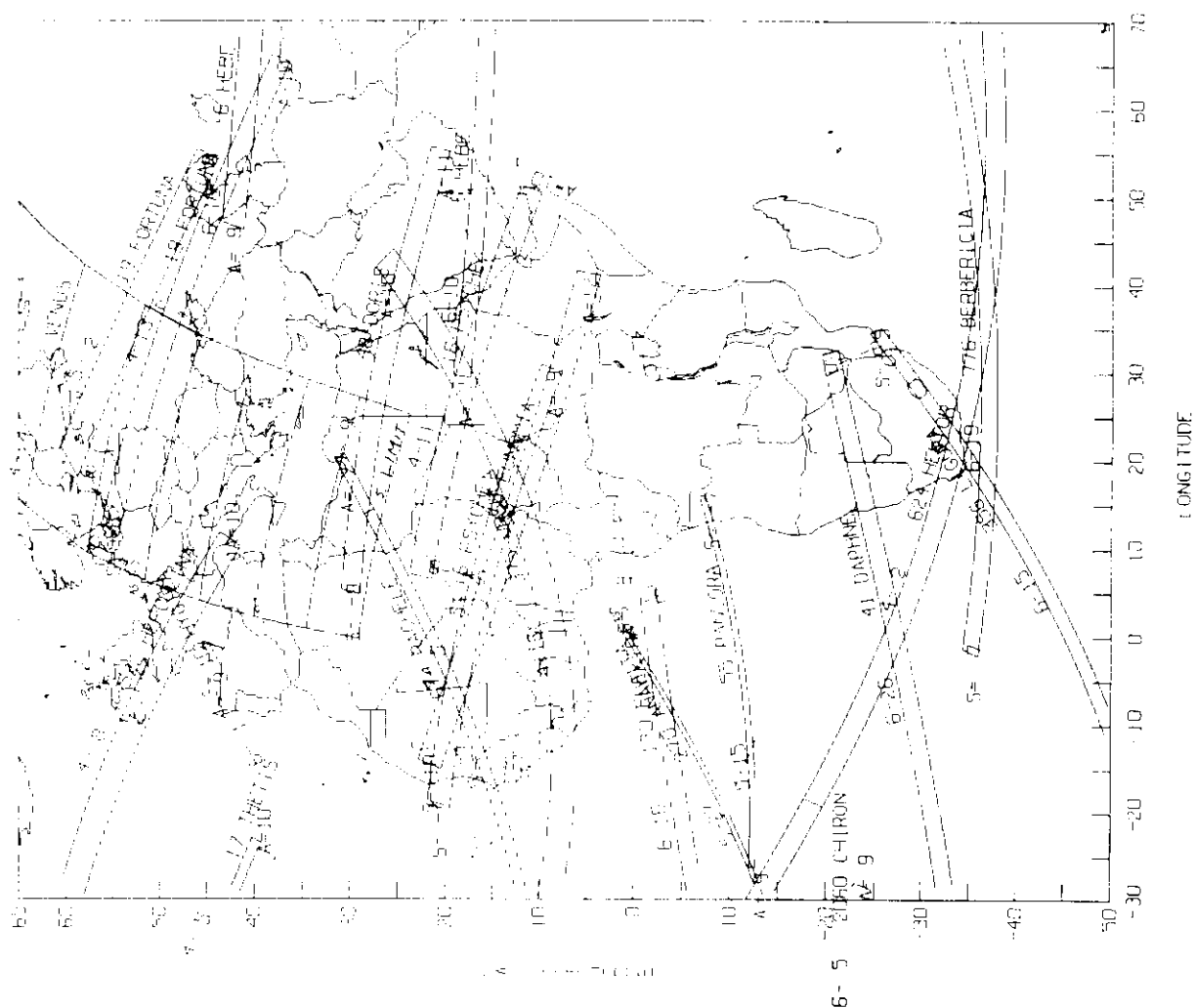
June 5: Chiron's large distance makes the path location very uncertain. Chiron is probably a giant comet, since it now has a coma.

June 10: The star is ZC 3281.

## PLANETARY ORBITATIONS, 1953, APR - JUNE



# PLACEMENT OF FLATTOPS ON MAP





June 11, Jupiter: Only the northernmost part of Jupiter will cover the star, so the actual event will be shorter than the listed central duration.

June 11, (694) Ekard: The star is ZC 2053 = Lambda Virginis, with 4.9 and 6.3-mag. components about 0"006 apart. So if the primary is occulted, there would be only about a 2-mag. drop, not 8 mags.

June 19, Venus: Venus will be 47% sunlit.

June 20: The star is ZC 418.

June 25, (53) Kalypso: The star is ZC 3112.

---

INTERNATIONAL WORKING GROUP ON REDUCTION OF  
OCCULTATIONS FORMED AT EILENBURG MEETING

David W. Dunham and Wolfgang Beisker

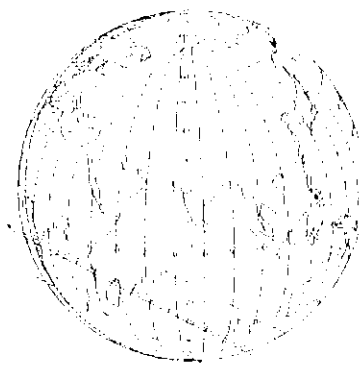
On October 6, we attended a meeting on occultations held at the Yuri Gagarin Observatory in Eilenburg, near Leipzig in the eastern part of Germany. IOTA/ES sent a report of this meeting for ON, but since this issue must be taken to the printer within a few hours, only some highlights of the report can be included this time. The discussions covered several aspects of occultations. The German Democratic Republic had fostered a strong educational program in astronomy, which resulted in the formation of many popular observatories such as the one where we met.

Welcome addresses were given by Mr. Beuchle, Dr. Otto, Mr. Bode, and David Dunham. A major item of discussion at the meeting was the reduction of occultation times, especially with MS-DOS PC-compatible software, some of which was demonstrated at the meeting. It was decided that local, national, and regional reduction centers could provide observers quicker feedback about their observations than can currently be accomplished. So a working group was formed to survey existing software and databases, and later decide the best way to implement reduction programs that could be used by many observers in different countries. Reinhold Buechner agreed to chair the working group, and Hans Bode, chairman of IOTA/ES, would act as the working group's secretary for the time being. Other first members of the working group are Dr. Costa (Italy), Federspiel, Katerbaum, Riedel, Zimmer, and Zimmermann. If you are performing occultation calculations, especially aimed towards reducing timings, please send a short note to Mr. Bode briefly describing your hardware, existing software and data, and what you might like to have in the future. A fuller account of the Eilenburg meeting, and progress of the working group, will be published in the next ON.

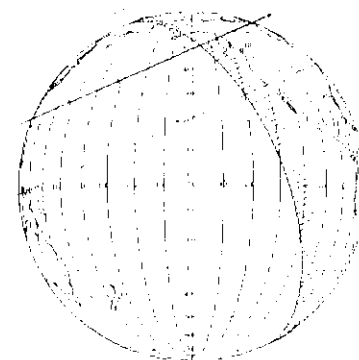
After the Eilenburg meeting, I attended the 41st congress of the International Astronautical Federation in Dresden. One day, Gunnar Katerbaum of the Technical University gave me a tour of their observatory, and also gave me a copy of his recently completed Ph.D. dissertation on photoelectric observation and analysis of lunar occultations.

Table 3. Stellar Angular Diameter Information.

| 1991<br>Date | P L A N E T<br>No. Name | S T A R D<br>SAO/DM No | Stellar Diameter |      |      |      |
|--------------|-------------------------|------------------------|------------------|------|------|------|
|              |                         |                        | m"               | m    | time | df   |
| Jan 4        | 4 Vesta                 | 93228                  | 0.23             | 317  | 82   | 1.2  |
| Jan 13       | 381 Myrrha              | 95912                  | 1.27             | 2364 | 156  | 7.5  |
| Jan 23       | 51 Nemausa              | 146465                 | 2.58             | 5943 | 149  | 16.9 |
| Mar 6        | 356 Ligura              | 210241                 | 1.76             | 4625 | 184  | 12.3 |
| Mar 17       | 334 Chicago             | 162723                 | 0.66             | 1931 | 68   | 4.9  |
| Mar 24       | 694 Ekard               | 183265                 | 0.21             | 336  | 78   | 1.2  |
| Mar 28       | 9 Metis                 | 79974A                 | 0.62             | 762  | 93   | 3.0  |
| Apr 2        | 624 Hektor              | 181911                 | 0.30             | 898  | 58   | 2.2  |
| Apr 23       | 156 Xanthippe           | 144968A                | 1.51             | 2608 | 113  | 8.6  |
| Apr 28       | 433 Eros                | 227542A                | 0.71             | 317  | 83   | 2.0  |
| Apr 28       | 433 Eros                | 227542B                | 0.43             | 191  | 50   | 1.2  |
| Jun 3        | 25 Phocaea              | 106792                 | 1.94             | 1734 | 111  | 7.9  |
| Jun 11       | 694 Ekard               | 158489U                | 0.48             | 639  | 76   | 2.4  |
| Jun 15       | 356 Ligura              | 210543                 | 0.82             | 1402 | 102  | 4.6  |
| Jun 25       | 53 Kalypso              | 164279                 | 0.21             | 349  | 63   | 1.2  |
| Jul 31       | 23 Thalia               | 210502                 | 0.97             | 1598 | 145  | 5.4  |
| Aug 8        | 432 Pythia              | 166014                 | 0.42             | 415  | 59   | 1.8  |
| Aug 23       | 404 Arsinoe             | 185353                 | 0.56             | 723  | 78   | 2.8  |
| Aug 27       | 3 Juno                  | 142983                 | 0.31             | 467  | 59   | 1.7  |
| Aug 28       | 139 Juewa               | 58852                  | 3.44             | 7592 | 240  | 22.1 |
| Sep 10       | 536 Merapi              | 129630                 | 0.48             | 822  | 111  | 2.7  |
| Sep 14       | 5 Jupiter               | 98990                  | 0.85             | 3895 | 97   | 7.9  |
| Sep 26       | 432 Pythia              | 191893                 | 0.82             | 824  | 102  | 3.6  |
| Oct 26       | 171 Ophelia             | 146537A                | 0.14             | 288  | 54   | 0.9  |
| Nov 1        | 363 Padua               | 93261                  | 0.49             | 573  | 52   | 2.3  |
| Nov 30       | 6 Hebe                  | 191604                 | 0.96             | 1147 | 60   | 4.5  |
| Dec 12       | 22 Kalliope             | +25° 733               | 1.12             | 1340 | 110  | 5.3  |
| Dec 25       | 75 Eurydike             | 139305                 | 0.58             | 1493 | 61   | 4.0  |
| Dec 25       | 51 Nemausa              | 112355                 | 0.62             | 646  | 65   | 2.7  |
| Dec 30       | 287 Nephthys            | 95637                  | 0.85             | 888  | 76   | 3.8  |
| Dec 31       | 50 Virginia             | 93933K                 | 0.22             | 205  | 51   | 0.9  |



Anonymous by Herculina 91 Jan 14



B5432207 by Ida 1991 Jan 15

## NEW DOUBLE STARS

Tony P. Murray

This is the resumption of the reports on occultation double star discoveries that last appeared in ON 2 (9), p. 98-100. It is my purpose to prepare the reports for each issue of ON, or as often as will be sufficient for its purpose. From 1981 to now, only 9 reports have been received from IOTA amateur astronomers who have discovered previously unknown double stars while timing lunar occultations. The majority of the 62 new double stars listed below were found in reports in two astronomy journals. As reports become available from other sources, they will be duly reported here. The data concerning new double stars will be made available to those who can further study them.

I am concerned about the low number of reports from IOTA members. Since it has been 9 years since occultation double star discoveries were systematically recorded and published, I am sure that there are many more discoveries that have not been reported to me. Therefore, if you have sent a report of a possible new double star (from an observed step event or gradual disappearance or reappearance) to ILOC or to someone else in IOTA from 1981 to now, please send a copy to me at Route 1, Box 67; Georgetown, GA 31754; U.S.A.

We should standardize new reports to reduce confusion. Please use a copy of the standard ILOC (or equivalent IOTA graze) report form and write at the top left of the front side, "Report of possible double star - SAO xxxxxx". If the star is not in the SAO, give its DM number. If more than one possible double was observed, give numbers for all listed. Give the information that Dunham requested in ON 4 (16), p. 359: Date, time of disappearance or reappearance, place of observation, method of observation, and steadiness and transparency of the atmosphere (all of these are already requested on the report form). In addition, in the comments section on the back, give estimates of the duration of fade for gradual events, or of the duration and magnitude drop or increase for step events, the position angle and cusp angle of the event, percent of Moon sunlit, your certainty of the phenomenon (possible, probable, or certain), and any other circumstance that might affect the observation. It is helpful to also report the star's magnitude and (if any) double star code given in your predictions.

Over time, we expect to provide follow-up as to the results of your discoveries. It may take some time to confirm your observation, but we understand the interest you have in this. I invite you to write with comments, suggestions, and questions on observing experiences, techniques, etc.

Visual observers normally will not notice the duplicity of code U (separation less than 0".01) doubles, since the diffraction patterns of the two components will interfere, precluding definite "step" events. Visual observers should watch for disappearances or reappearances in distinct steps to signal the discovery of a close double. In the case of very close doubles, the two steps can not be resolved by the

eye, which perceives them as a quick, continuous fade. During total occultations, this often denotes duplicity, but during favorable grazes, continuous fades or brightenings are often due to diffraction of the star's light at the Moon's edge. For totals more than 40° of p.a. away from being a graze, a fade event more likely would be due to duplicity than to diffraction, whereas the reverse would be true during a graze. Atmospheric seeing and, for faint stars, irradiation, may also have an effect.

The table lists 62 additions and revisions to the IOTA zodiacal double star file, DSFILE. Actually, 14 of the stars are already in DSFILE, but these have not been reported in previous issues of ON. These 14 stars are indicated with short dashes following the SAO number, which is given in the first column. If the star is not in the SAO, its DM number is given, and the USNO reference number is given if it is also not in DM). When applicable, the Zodiacal Catalog (ZC) number is given in notes. An asterisk after the SAO number indicates revised data for a known component of a double or multiple system. The method used to obtain the data is indicated under M. The meanings of the method codes used under this column are listed below:

- A: Composite spectrum - separation given as 0".05, although it is unknown (but likely to be in the range 0".01 to 0".2).
- C: Correct error.
- E: Eclipsing binary lightcurve.
- G: Grazing occultation.
- I: Intensity or speckle interferometry.
- L: Combination of two photoelectric or video total occultation observations made the same night, but at similar position angles so that the true separation (SEP) and position angle (PA) are poorly determined.
- P: Photoelectric total occultation.
- Q: Videorecorded total occultation.
- S: Spectroscopic analysis - orbital elements of spectroscopic binary determined, or at least variable radial velocity noted (in which case, 0".05 is used for SEP; see A above).
- T: Visual total occultation.
- U: Revised data of known double from photoelectric total occultation. The magnitudes are revised; the SEP and PA are also revised if they previously were only estimated by T.
- V: Direct visual double star observation, including visual interferometry.
- X: Combination of two photoelectric or video total occultation observations, or one P or Q and one well-determined G, obtained the same night at well-separated p.a.'s.
- Y: Combination of P or Q and T, or P or Q and G, with magnitudes determined from P or Q.
- Z: Combination of 2 T's, or T and G.

Combined occultation solutions are preferred, since with only one P, Q, or T, and usually with only one G, the true separation and p.a. are not known, but only their projections onto the p.a. of the observed event. For I, there is usually a 180° ambiguity in PA.

The star's new double star code is given under N. A list describing the double star codes is given in the

"Notice to Observers" dated 30 September 1976 distributed by the U. S. Naval Observatory (USNO). If you do not have this notice, you can obtain a copy by sending a self-addressed envelope to either the McManuses or to me. Two new double stars are not in USNO's list:

- G: Triple, A or C, with secondary either J, U, or V (3rd star's data are referred to secondary).  
 S: Triple, M, with secondary either J, U, or V (3rd star's data are referred to secondary).

Numerical double star codes (1, 2, and, rarely, 3) are used for some non-SAO AGK3 stars in the XZ catalog; they usually refer to preceding and following components.

SEP and PA are the separation (in arc seconds) and position angle (in degrees) of the secondary star with respect to the primary, respectively. MAG3, EP3, and PA3 refer to a third component, if any (these are not given, and mostly are not applicable, in my table this month). No entry under PA means it is changing (significant orbital motion) or has not been determined (spectroscopic or spectrum binary).

Under Date, the year (minus 1900), month, and day of month are given. The discoverer's family name is given under Disc. Notes about individual events follow the table. In the notes, ADS refers to the number in Aitken's Double Star Catalog.

Notes for the Table. The names and locations of the discoverers, where only last names are given under Disc, are listed below:

Graham Blow, McDonald Observatory, Texas  
 David Edwards, McDonald Observatory, Texas  
 David Evans, McDonald Observatory, Texas  
 Tony Murray, Georgetown, Georgia  
 Richard Radick, Urbana, Illinois  
 Robert Sandy, Blue Springs, Missouri  
 James Van Nuland, San Jose, California  
 Richard Wilds, Topeka, Kansas

Sandy and Wilds did not observe from their home cities, but from locations that are given in the tables published with Don Stockbauer's grazing occultation articles. "et.al." following Wilds indicates that other members of his graze team independently discovered the duplicity. Graham Blow, from Wellington, New Zealand, was a visiting astronomer at the University of Texas when he made his observations.

Most of the new doubles were discovered during observing runs at McDonald Observatory from 1978 to 1986. They are reported in their series of articles, "Photoelectric Observations of Lunar Occultations", number XI to XVI, in the Astronomical Journal. For example, Paper XV was in AJ 90 (11), p. 2360; others can be found in the AJ indices since David S. Evans was one of the authors of all of these papers. The two events observed by Radick were reported in AJ 85, p. 1053 (1990), and also in David Evans' catalog in his article, "The Discovery of Double Stars at Occultations" on pages 63 - 90 of the proceedings of IAU Colloquium No. 62, "Current Techniques in Double and Multiple Star Research" held at Flagstaff May 19-

21, 1981, and published as Lowell Observatory Bulletin No. 167, edited by Robert S. Harrington and Otto G. Franz. For visually observed occultations, the separation is given as 0"1 for total occultations and 0"05 for grazes, unless reported durations indicate larger separations.

Notes for individual SAO stars are given below:

- 076472: Graze reported in ON 4 (15) p. 363. Wilds noted step events, others saw fades.  
 076971: The star is ZC 765 = 106 Tauri.  
 077813: The star is ZC 905.  
 092922: The star is ZC 352.  
 092979: Not in table. The star is ZC 370 = 26 Arietis. Sandy's 90Sep09 graze observation confirms previously suspected duplicity, so code should be changed from K to V.  
 093803: The star is ZC 618.  
 094554: The star is ZC 814 = 115 Tauri = ADS 4038A. The visual B-component, mag. 10.1, is 10"1 away in p.a. 306°.  
 094586: The star is ZC 823 = ADS 4073A. The visual B star, mag. 10.1, is 3"4 away in p.a. 133°.  
 097472: The star is ZC 1207 = 3 Cancri.  
 098711: Not in table. The star is ADS 7481, a visual double noted by Jeffers and Bos to have sep. 0"4 in 1958. Evans gives sep. as 0"25 on 83May19, so orbital motion is evident. Star is already in DSFILE.  
 099012: The star is ZC 1498.  
 099206: The star is ZC 1552.  
 110295: The star is ZC 300.  
 119125: The star is ZC 1725.  
 138892: The star is ZC 1815 = Chi Virginis. The graze was reported in Sandy's article in ON 4 (11), p. 258 and 259.  
 139794: The star is ZC 2035.  
 163811: Not in table. Observation 1980 Oct. 18 by Van Nuland confirms previously claimed duplicity.  
 164657: The star is ZC 3191.  
 165359: The star is ZC 3356 = 74 Aquarii.  
 186614: Near graze.  
 187716: Graze videorecorded; see G. Hug's article in ON 4 (14) p. 340. In that article, the star was incorrectly identified as SAO 187717. The star also has an 8.6-mag. visual companion 45" away in p.a. 124°.  
 188722: The star is ZC 2910 = Omega Sagittarii. The mag. diff. was not given and assumed zero.  
 189903: The star is ZC 3068.

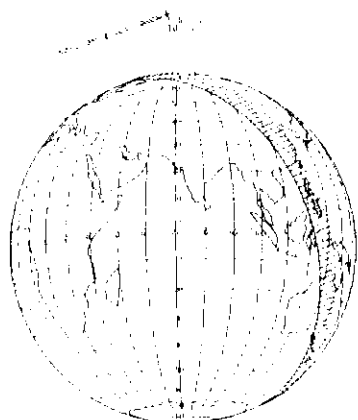
Special thanks go to John Green at American Buildings Company, Eufaula, Alabama, for teaching me how to use a PC so that I could do this work.

#### I. SATO'S ZODIACAL CATALOG J2000 AVAILABLE

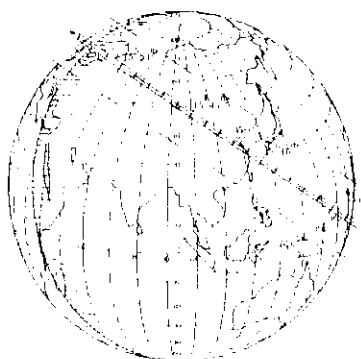
When Mitsuru Soma visited us in October, I bought ten copies of Isao Sato's version of the Z.C., "Catalog of 3539 Zodiacal Stars for the Equinox J2000.0". Now that the Uranometria 2000.0 and other equinox 2000 star atlases are becoming popular, Sato's ZC will become more useful. Sato's tables contain much more information than Robertson's original ZC, which is out of print. Sato gives DM, SAO, and AGK3 numbers,



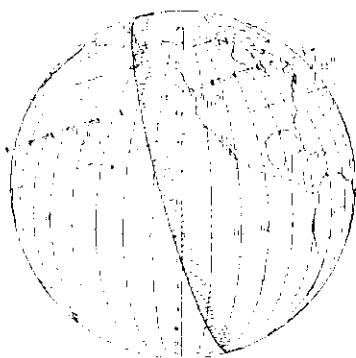
as well as comprehensive tables of information about zodiacal double and variable stars. Tables of zodiacal clusters, nebulae, galaxies, radio sources, and X-ray sources are given, along with ecliptic-coordinate plots of all of the cataloged sources. He also gives formulae and tables for computing apparent star positions, lunar positions, lunar eclipses, total and grazing occultations, and librations, but the explanations are in Japanese. The headings for all tables, however, are in English. To get a copy of the book, send a check or money order for \$17.00 payable to: David W. Dunham; 7006 Megan Lane; Greenbelt, Maryland 20770; USA.



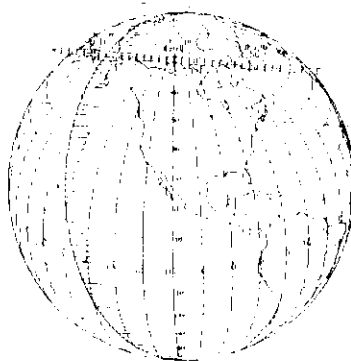
SAO 146465 by Nemausa 91 Jan 23  
= ZC 3383 = 82 Aquarii



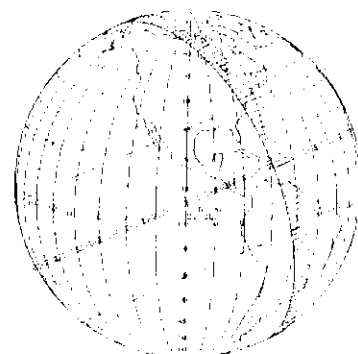
Anonymous by Herculina 91 Jan 26



Anonymous by Hestia 1991 Feb 2



Anonymous and Hermione 1991 Feb 3



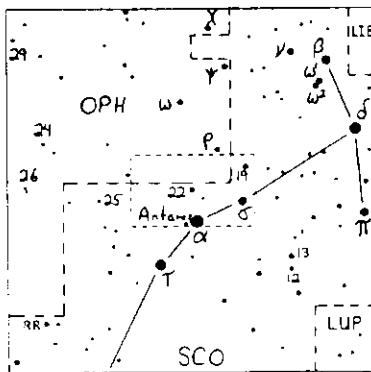
SAO 92170 by Juewa 1991 Feb 5

| SAO    | M | N | Mag1 | Mag2 | Sep   | PA    | Date    | Disc          |
|--------|---|---|------|------|-------|-------|---------|---------------|
| 076472 | G | V | 8.3  | 8.3  | .05   | 360   | 90Feb04 | Wilds et.al.  |
| 076971 | P | K | 5.7  | 6.7  | .005  | 349.4 | 82Aug14 | Evans         |
| 077070 | T | V | 9.4  | 9.4  | .1    | 50    | 86Mch18 | Murray        |
| 077337 | P | V | 9.4  | 10.3 | .027  | 250   | 85Mch01 | Evans         |
| 077473 | P | K | 9.0  | 10.6 | .054  | 243.6 | 84Mch11 | Evans         |
| 077813 | P | V | 7.1  | 8.0  | .007  | 20.9  | 82Mch04 | Evans         |
| 078488 | T | V | 9.5  | 9.5  | .1    | 142   | 88Feb27 | Murray        |
| 079122 | T | K | 8.7  | 8.7  | .1    | 116   | 85Mch30 | Van Nuland    |
| 092922 | P | K | 7.4  | 10.2 | .031  | 229.1 | 79Jan07 | Edwards       |
| 092929 | P | K | 8.7  | 10.7 | .023  | 191.6 | 84Feb09 | Evans         |
| 093067 | P | V | 6.9  | 7.2  | .01   | 21    | 81Nov11 | Blow          |
| 093411 | T | V | 9.3  | 9.3  | .1    | 09    | 82Feb02 | Van Nuland    |
| 093759 | P | V | 9.1  | 9.6  | .065  | 254.4 | 81Feb11 | Evans         |
| 093801 | P | V | 7.3  | 10.0 | .058  | 79.9  | 78Oct16 | Edwards       |
| 094554 | P | T | 5.7  | 6.6  | .1082 | 98    | 78Feb17 | Evans         |
| 094586 | P | T | 7.3  | 7.5  | .0157 | 232.2 | 80Jan28 | Evans         |
| 094595 | P | V | 9.7  | 9.8  | .92   | 64    | 81Sep20 | Blow          |
| 094961 | P | V | 8.3  | 10.2 | .02   | 219.3 | 79Apr03 | Edwards       |
| 095258 | P | X | 8.1  | 10.5 | .006  | 50.5  | 79Dec05 | Evans         |
| 095728 | P | V | 9.6  | 9.7  | .1    | 138.2 | 78Nov18 | Edwards       |
| 096810 | P | V | 8.7  | 11.0 | .175  | 213.1 | 78Apr15 | Edwards       |
| 097472 | P | X | 6.0  | 7.6  | .003  | 240.6 | 79Dec07 | Evans         |
| 098519 | P | X | 8.7  | 9.6  | .232  | 279.5 | 79Apr07 | Edwards       |
| 098770 | P | V | 9.4  | 9.8  | .288  | 136   | 81May11 | Blow          |
| 098824 | P | K | 9.1  | 10.3 | .5    | 73    | 83Apr22 | Evans         |
| 098828 | P | V | 9.6  | 9.7  | .10   | 168   | 83Apr22 | Evans         |
| 099012 | P | K | 8.4  | 9.4  | .08   | 94.4  | 80Mch28 | Evans         |
| 099202 | P | X | 7.7  | 10.2 | .38   | 285.6 | 83May20 | Evans         |
| 099206 | P | V | 9.3  | 9.4  | .035  | 111   | 81May12 | Blow          |
| 109760 | P | K | 9.7  | 10.3 | .08   | 83.1  | 82Sep06 | Evans         |
| 110026 | P | K | 9.7  | 9.8  | .05   | 72.4  | 84Feb08 | Evans         |
| 110295 | P | V | 8.2  | 9.2  | .028  | 227.5 | 78Nov13 | Edwards       |
| 118253 | P | V | 9.1  | 9.9  | .013  | 174.7 | 78Nov16 | Edwards       |
| 118571 | P | V | 8.0  | 8.8  | .034  | 104.5 | 79Apr09 | Edwards       |
| 119125 | P | V | 8.1  | 8.4  | .029  | 270.4 | 84May11 | Evans         |
| 138892 | G | V | 4.8  | 8.8  | .1    | 214   | 88Dec31 | Wilds, Sandy  |
| 139794 | P | V | 7.4  | 8.6  | .051  | 92    | 81Jun13 | Blow          |
| 146289 | P | V | 8.9  | 9.4  | .017  | 259.4 | 78Oct03 | Edwards       |
| 146607 | T | V | 9.6  | 9.6  | .1    | 82    | 87Dec06 | Van Nuland    |
| 147021 | P | K | 9.5  | 9.7  | .067  | 235   | 82Jan02 | Blow          |
| 158604 | P | X | 9.0  | 9.3  | .008  | 80    | 78Jul15 | Edwards       |
| 159188 | P | K | 7.8  | 8.9  | .246  | 310.9 | 78Jun18 | Edwards       |
| 159933 | P | X | 9.3  | 10.6 | .189  | 265.5 | 78Aug13 | Edwards       |
| 160947 | P | V | 9.0  | 10.3 | .055  | 133.2 | 78Jul18 | Edwards       |
| 161202 | P | V | 9.6  | 10.7 | .203  | 259.8 | 79Aug05 | Evans         |
| 161245 | P | K | 8.9  | 10.4 | .62   | 281   | 78Apr27 | Radtke        |
| 161255 | P | K | 8.0  | 8.6  | .08   | 280   | 78Apr27 | Radtke        |
| 164259 | P | X | 9.3  | 10.6 | .241  | 6.8   | 79Oct02 | Evans         |
| 164482 | P | X | 9.3  | 10.9 | .042  | 235.7 | 78Nov08 | Edwards       |
| 164657 | P | V | 7.7  | 9.4  | .017  | 13.2  | 83Sep19 | Evans         |
| 165239 | P | K | 8.5  | 11.1 | .03   | 316   | 84Nov03 | Evans         |
| 165359 | P | V | 6.4  | 7.0  | .013  | 298   | 81Nov07 | Blow          |
| 183864 | P | K | 8.1  | 11.7 | .36   | 152.6 | 84Jul09 | Evans         |
| 184558 | P | X | 8.9  | 10.5 | .043  | 245   | 82Aug27 | Evans         |
| 186614 | T | V | 9.7  | 9.7  | .05   | 13    | 83Sep15 | Van Nuland    |
| 187716 | G | V | 7.8  | 7.8  | .05   | 160   | 89Oct08 | Wilds, et.al. |
| 187824 | P | K | 9.1  | 11.4 | .12   | 64.3  | 84Sep05 | Evans         |
| 187861 | P | V | 9.2  | 9.3  | .10   | 36.3  | 85Jul30 | Evans         |
| 187885 | P | V | 9.9  | 10.3 | .047  | 326   | 82Aug30 | Evans         |
| 188722 | P | K | 5.6  | 5.6  | .0017 | 51.3  | 85Aug27 | Evans         |
| 189903 | P | X | 7.9  | 10.4 | .047  | 326   | 83Aug30 | Evans         |
| 189912 | P | V | 8.6  | 10.0 | .065  | 265   | 84Sep07 | Evans         |

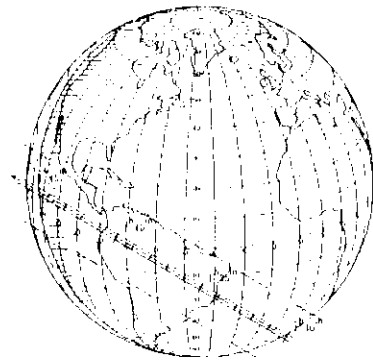
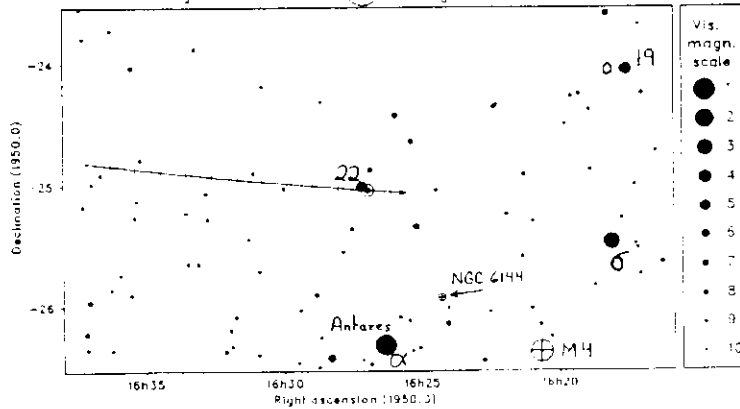
## 674 Rachele - SAO 184425

1991 may 27 3h13.2m U.T.

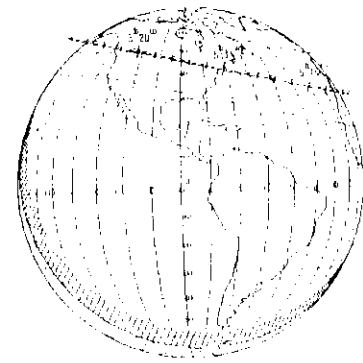
| Minor planet :           |                         |                 | Star :                                                 | Source cat. Yate                 |
|--------------------------|-------------------------|-----------------|--------------------------------------------------------|----------------------------------|
| V. mag. = 12.13          | Diam. = 95.9 km = 0.06" |                 | $\alpha = 16^{\text{h}}26^{\text{m}}56.676^{\text{s}}$ | $\delta = -25^{\circ}02'19.44''$ |
| $\mu = 32.15''/\text{h}$ | $\pi = 3.71''$          | Ref. = MPC 4377 | V. mag. = 7.32                                         | Ph. mag. = 7.58                  |
| $\Delta m = 4.8$         | Max. dur. = 6.2 s       |                 | Sun : 174°                                             | Moon : 19° . 98%                 |



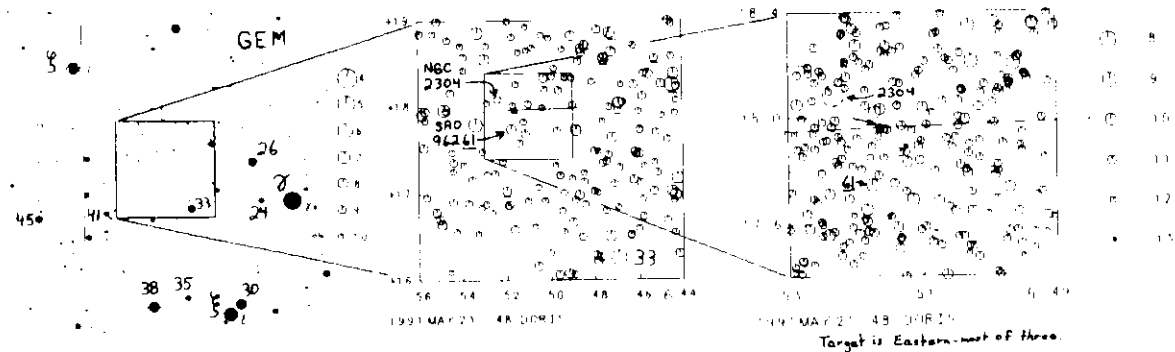
Enlargement 22 Target



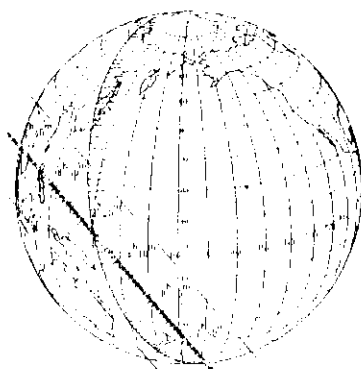
L 1 954 by Herculina 1991 Jan 19



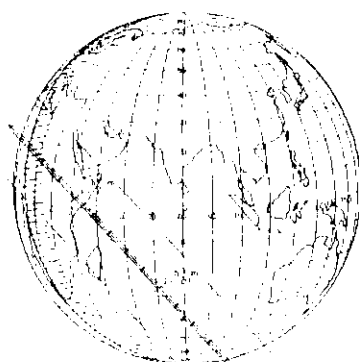
SAO 115296 by Kleopatra 91 Jan 19



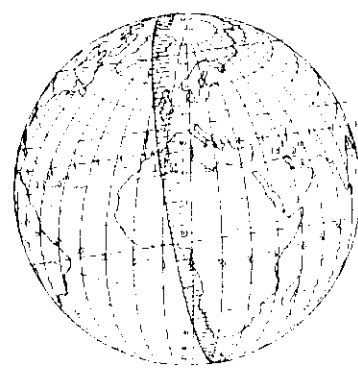
Target is Eastern-most of three.



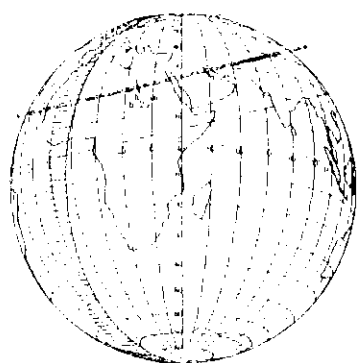
A21°43855 by Thetis 1991 Feb 10



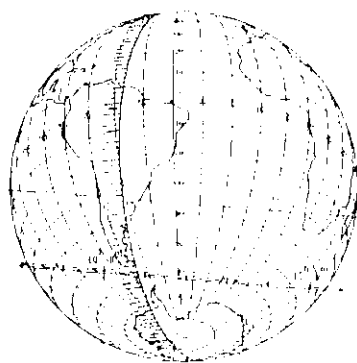
L 1 4701 by Eunike 1991 Feb 20



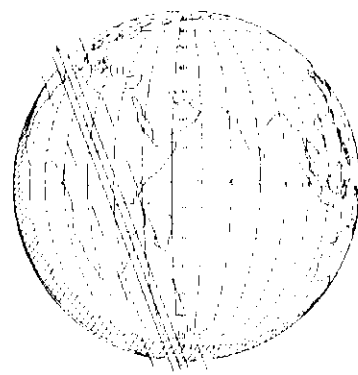
SAO 76660 by Mars 1991 Feb 21



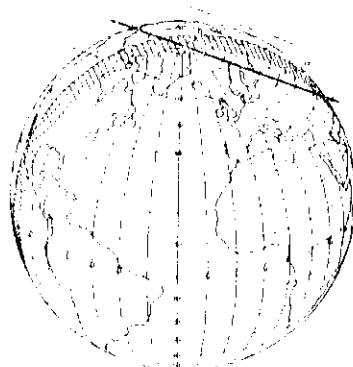
L 5 1476 by Melete 1991 Mar 5



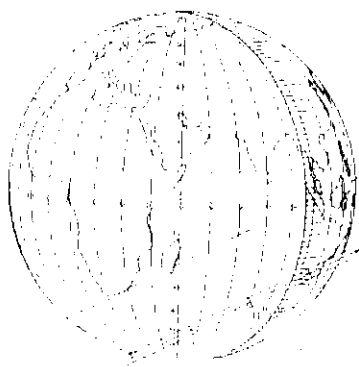
SAO 210241 by Ligura 1991 Mar 6



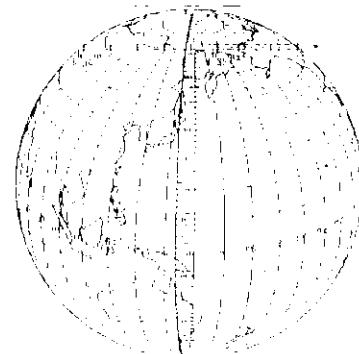
SAO 137817 by Pallas 1991 Mar 7



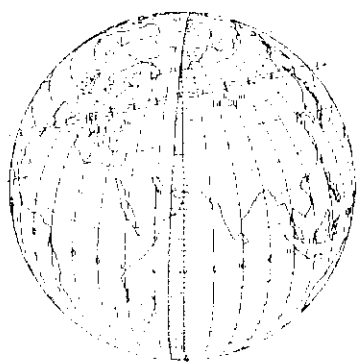
BD +26° 2149 by Aeria 91 Mar 16



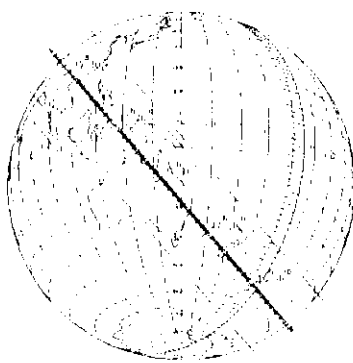
Anonymous by Davida 1991 Mar 17



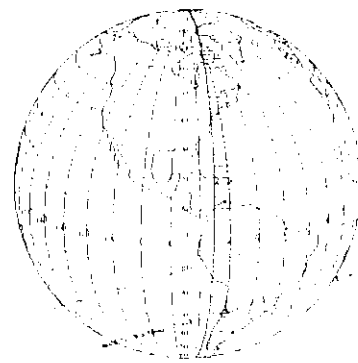
L 1 106 by Fortuna 1991 Mar 18



Anonymous by Herculina 91 Mar 24



SAO 183265 by Ekard 1991 Mar 24



A18°43076 by CarTova 1991 Mar 24

## 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:

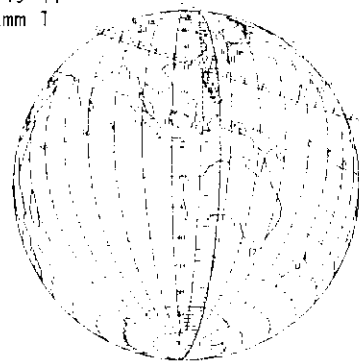
|                                     |                         |
|-------------------------------------|-------------------------|
| President                           | David W. Dunham         |
| Executive Vice President            | Paul Maley              |
| Executive Secretary                 | 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           |
| ON Editor                           | Joan Bixby Dunham       |
| IOTA/European Section President     | Hans-Joachim Bode       |
| IOTA/ES Secretary                   | Eberhard Bredner        |

Addresses, membership and subscription rates, and information on where to write for predictions are found on the front page.

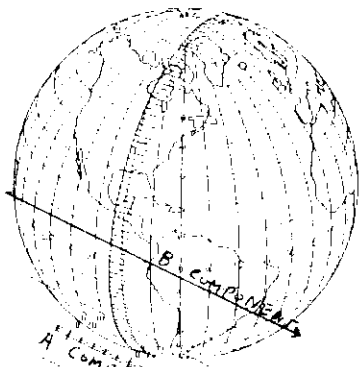
The Dunhams maintain the occultation information line at (301) 474-4945. Messages may also be left at that number.

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. The address for IOTA/ES is

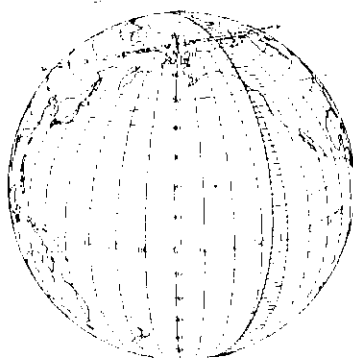
Eberhard Bredner  
Astrag VHS Hamm  
PO Box 2449-41  
D-4700 Hamm 1  
Germany



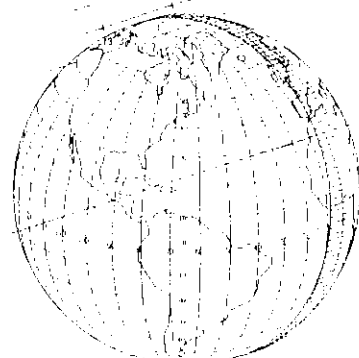
823° 65574 by Diotima 1991 Mar 27



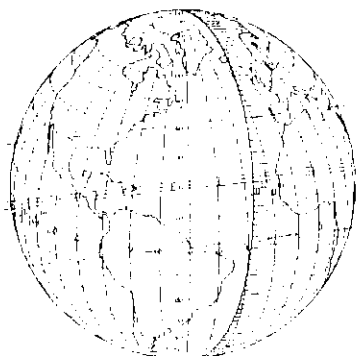
SAO 79974 by Metis 1991 Mar 28



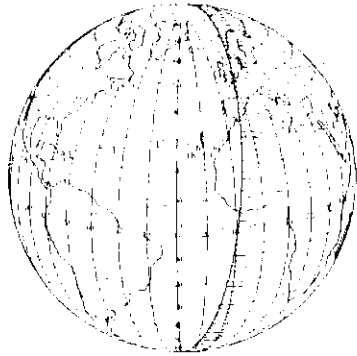
SAO 94021 by Hestia 1991 Apr 1



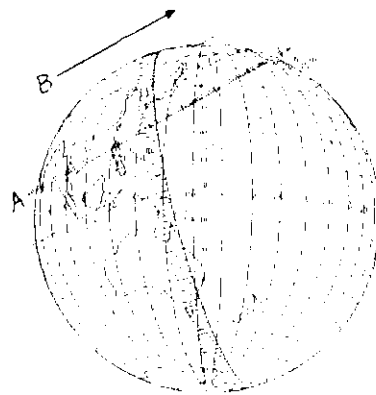
SAO 93319 by Venus 1991 Apr 4



SAO 77145 by Psyche 1991 Apr 5



Anonymous by Doris 1991 Apr 9



SAO 144968 by Xanthippe 1991 Apr 23  
= ZC 3063 = 7 Aquarii