Occultation Newsletter

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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.

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for all others 25.00
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ON 1 (1) through ON 4 (1), each 2.50
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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 DOURBES; Belgium) or IOTA/ES (see below), for southern Africa through M. D. Overbeek (Box 212; Edenvale 1610; 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 N. Joi Drive; Tucson, AZ 85737; U.S.A.) for 2.50

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

IOTA NEWS

David W. Dunham

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. Boninsegna 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.

AJ 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 photoelectric 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:

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

Phone:
(913) 271-7187

REPORTS OF ASTEROIDAL APPULSES AND OCCULTATIONS

Jim Stamm

If you do not have a regional coordinator who forwards your reports, they should be sent to me at: 11781 N. Joi Dr., Tucson, AZ 85737, USA. Names and addresses of regional coordinators are given in "From the Publisher" on 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 18; [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 ±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 Boninsegna describes two events on 1989 October 23 in the following article.

EUROPEAN SECTION ASTEROIDAL OCCULTATION RESULTS

Roland Boninsegna

<u>(521) Brixia and SAO 147658, 1989 October 23:</u> 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 <u>ON</u>.

<u>146 Lucina and FAC 212517 on 1989 October 23:</u> 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., <u>Celestial Mechanics</u> <u>45</u>, 129, 1989).

An occultation of 26.6 duration was recorded at Pic-du-Midi beginning at $23^h\ 56^m\ 57.4^s$. 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 $23^h\ 54^m\ 19.9^s$, and two blinks, one at $54^m\ 59.0^s$ and the other at $54^m\ 38.2^s$. 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.

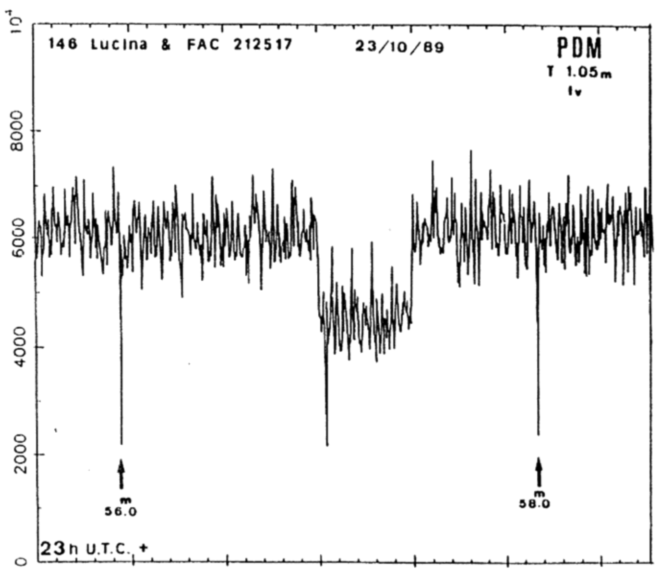


Fig. 1: Light curve of the occultation of FAC 212517 by 146 Lucina from the video recording made at Pic-du-Midi.

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 <u>ON 4</u> (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 <u>The Washington Post</u>.

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°S and Moon altitude 28°.

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.

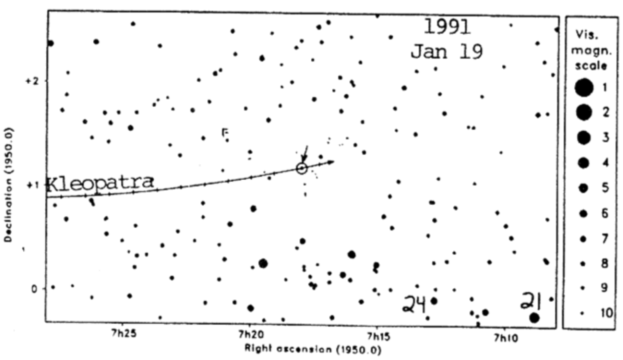
For Kleopatra, the predicted magnitude drop is 1.7, since the target star's visual mag. is 9.1, which seems to be confirmed by inspection of the True Visual Magnitude Atlas (TVMA). Hence, the larger magnitude drop given in the 1991 Asteroidal Occultation Supplement distributed with the last issue is 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 distributed 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".01 or 0".02 intervals of shift values, and distribute these to regional coordinators. Tracks will be numbered at intervals of 0".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.

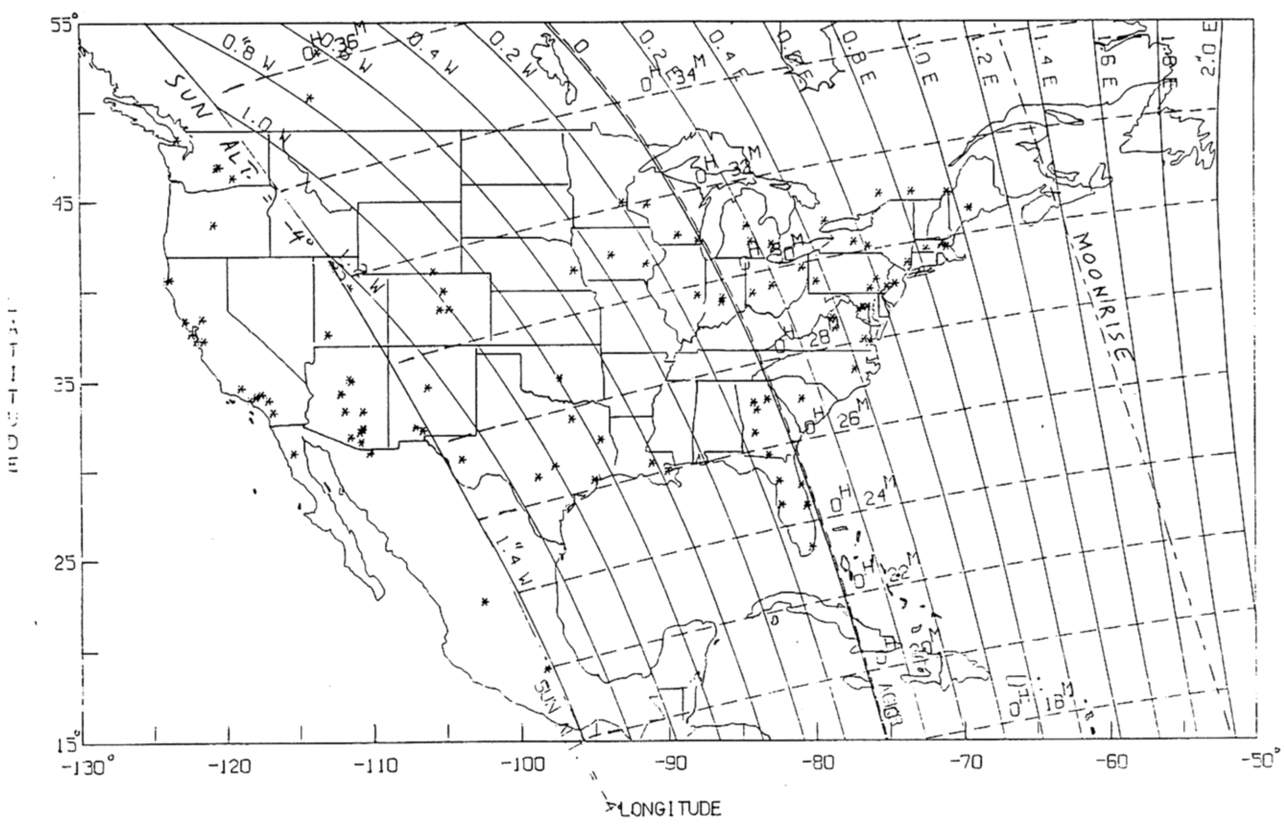
The predicted path for the Vesta occultation shown on the world maps by Goffin (in the Supplement) and by Soma are significantly east of my nominal path in North America. Soma used basic data provided by me, but since the Earth is shown only at the time of closest approach, and Vesta's motion is so slow, 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.

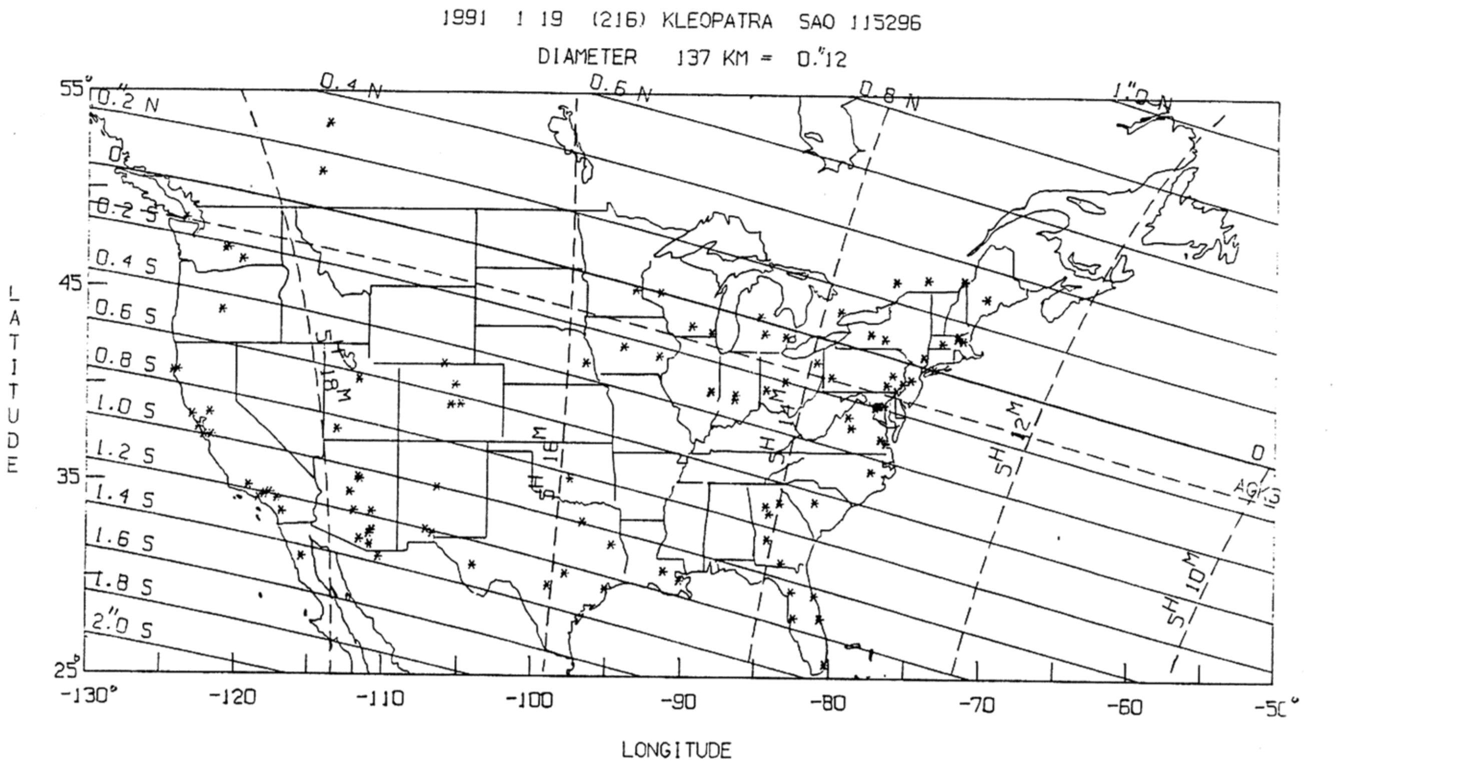
Coordination: Regional and local coordinators are sought to organize the overall effort. They will work with me to determine the track numbers (or the longitudes and latitudes so that I can determine the track numbers) of fixed-site observers and observatories in their region. Also, we need to identify 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 last astrometry is available as well as an estimate of which regions may have clear skies. Additional updates may be made the morning of the 3rd, when the weather pattern will be known better. Please telephone me at 301,474-4722 if you can coordinate the effort in your state, province, or local area. Most coordination will be by telephone, so work and home phone numbers will be useful, as well as significant amounts of time that you may be unreachable around Jan. 1 (no coordination will be done the evening of Dec. 31!). Some coordination can be done by fax, if this is available to you (my fax number is 301,794-4377), or by e-mail, available now at most colleges and universities (I am on SPAN at nssdca::dunham or nssdcb::dunham). I will be the regional coordinator for the mid-Atlantic states region (MD, DC, VA, eastern PA, and NJ). Harold Povenmire, phone 407,777-1303, will be the coordinator for FL, and possibly also GA. Philip Dombrowski, Glastonbury, will coordinate for CT, phone 203,659-1783. Prospective local coordinators should contact the coordinator for their region, or me if their regional coordinator is not known.

Astrometric Updates: A first astrometric update for the Vesta occultation, from plates that will probably 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 4 (4) VESTA SAO 93228

DIAMETER 561 KM = 0.″41





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°2 wide and about 0°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 Reitsema 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

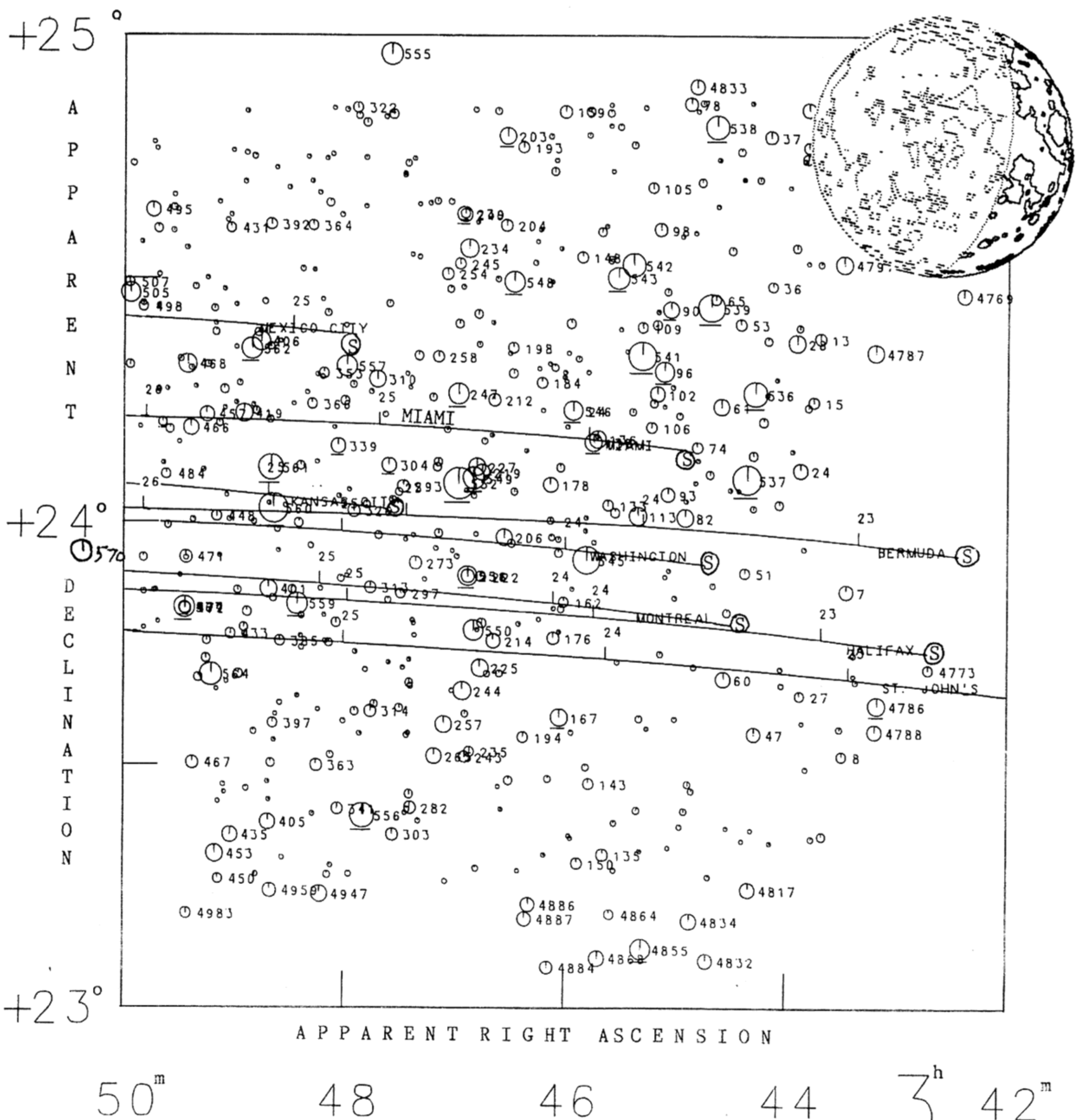
OCCULTATIONS OF NEBULAE DURING 1991, EXCLUDING THE PLEIADES

UT date			Nebula	Type	Mag.	diam.	% sunl.	dur.	Area of visibility
Mar.	8,	12^h	NGC6293	globular	8.4	1!9	49–	5^m	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 1990 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 ±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 ILE 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 0h 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 SMBDN 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 analyses 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 R.A. 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 their right ascensions are known to differ; in fact, the J2000 zero point was largely determined by analysis of lunar occultation observations. Since the OCC 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 ON 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 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.

Graze List as of 11/20/1990

Date YrMoDy	V P	Star #	Mag.	% Snl	CA	Location	# Sta	# Tm	S S	Ap Cm	Organizer	N CShS	WA	B
900716		0311	6.5	39-	10N	Hubbell, NE	5	28	1	20	Richard P. Wilds	8N	352	-61
900718	V	076259	7.3	21-	7N	Shipbourne, Eng.	10	51	1	9	H.J.T. Carpenter	0	357	-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	0	353	-62
900814		0541	4.0	43-	5N	Keene, KS	1	0	3	33	Richard P. Wilds	0	356	-55
900814		0541	4.0	43-	5N	Solon, IA	5	20	1	15	William J. Eby	1S	356	-55
900814		0541	4.0	43-	6N	Epoufette, MI	2	22	1	6	Craig A. McManus	0	355	-55
900816		078009	9.0	19-	7N	Manzanita Obs, CA	1	10	1	20	Richard P. Wilds	0	356	-36
900817		1030	3.2	14-	5N	Fraimbois, France	4	12	2	11	Jean Schwaenen	4S	359	-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	1S	171	70
900828		2276	5.6	48+	8S	Freeman, MO	6	38	2	8	Robert Sandy	5S	172	70
900909		0370	6.1	78-	6N	Prescott, KS	4	35	1	20	Richard P. Wilds	0	351	-60
900909		0370	6.1	78-	6N	Warrensburg, MO	2	17	1	9	Robert Sandy	0	351	-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	24S	169	57
900926		185274	8.3	40+	10S	Seneca, KS	3	7	1	20	Richard P. Wilds	18S	171	55
900930		3058	5.9	78+	16S	Dannebrog, NE	1	2	1	33	Richard P. Wilds	5S	163	1
901001		3186	6.7	86+	18S	Elmont, KS	5	13	1	20	Richard P. Wilds	2S	162	-14
901001		3186	6.7	86+	18S	Amazonia, MO	4	17	1	8	Robert Sandy	2S	162	-14
901024		185976	8.4	24+	17S	Rantoul, KS	1	2	1	33	Richard P. Wilds	8S	164	44
901026		188423	8.0	42+	15S	Frankfort, KS	3	18	1	20	Richard P. Wilds	5S	164	19
901026		2884	7.5	42+	17S	Frankfort, KS	4	26	1	20	Richard P. Wilds	5S	162	16
901026		2884	7.5	42+	17S	Craig, MO	2	18	2	9	Robert Sandy	1S	162	16
901028		164870	7.5	71+	15S	Conyers, GA	1	4	1	25	Mike Kazmierczak	0	165	-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	4N	187	3

SOLAR ECLIPSE NEWS

David W. Dunham

<u>1991 January 15:</u> 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 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.

<u>1991 July 11:</u> 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
(Eiderblick 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 Wofgang 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 from 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 Vingerhoets, 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 21st 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 McManuses in Topeka, KS), or from Don Stockbauer; 2846 Mayflower Landing; Webster, TX 77598; U.S.A.

Asteroidal Occultation Predictions by E. 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 Astrographic 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 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 ame 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 Δm 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 PLANET, m_v is the visual magnitude (photoelectric V-mag. when available), and Δ 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, Δm 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 Δm 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 Δm 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 "1"), 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 El Sun column. Under Moon, the elongation from the target star is given under El, the percent sunlit ("+" for waxing and "-" for waning phases) is given under %Snl, 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 Date	Universal Time	PLANET Name	PLANET m_v	PLANET Δ,AU	STAR SAO NO	STAR m_v	STAR Sp	STAR R.A.(1950)	STAR Dec.	Occultation Δm	Occultation dur	Occultation df	Occultation P	Possible Path LolLal	Possible Path LomLam	Possible Path LoeLae	El Sun	MOON El	MOON %Snl	MOON Up	Ephem. Source
Jan 1	22h 6-10m	Lucina	12.8	2.447		10.8	F8	13h 3m.2	8°27'	2.2	7s	16	25	52°16°	72°18°	113°18°	89°	75°	98-	all	MPC15384
Jan 3	19 28-40	Hermione	12.2	2.418		11.3		5 57.6	26 55	1.3	16	23	16	105-29	57-11	0-16	167	55	87-	e 24E	MPC12191
Jan 3	23 58-102	Vesta	7.4	1.908	93228	7.4	F5	2 57.4	10 27	0.8	145	70	5	-65-29	-76 18	-159 70	122	101	86-	none	Goffin86
Jan 5	13 16-30	Herculina	9.1	1.636		10.9		6 40.5	20 14	0.2	16	19	11	-133 -1	174 29	69 48	175	68	72-	e128E	Goffin88
Jan 7	2 34-49	Thetis	11.9	1.832		9.5		6 3.0	19 18	2.5	7	21	29	21-12	-36 7	-118 8	164	97	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-	e128W	MPC12191
Jan 9	13 38-54	Eunike	11.8	1.969		10.8	K5	9 19.0	1 16	1.4	16	26	17	-149-36	166 -7	112 16	144	76	33-	e166E	MPC14753
Jan 9	20 56-80	Fortuna	9.9	1.280		10.2		5 47.7	20 56	0.6	23	30	11	92 -2	42 10	-30 4	158	134	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	84 39	146 45	117	171	24-	none	Yeomans
Jan 10	18 35-48	Pathtenope	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-	e133E	MPC12686
Jan 11	17 5-17	Dejopeja	12.8	2.091	79496	10.1	A2	7 30.2	22 58	2.8	5	22	45	158-32	108-14	41-19	179	133	16-	e133E	EMP 1983
Jan 12	13 6-23	Lydia	11.9	1.881	78343	8.8	G0	6 22.3	29 36	3.1	8	23	31	-133 0	168 25	79 17	162	159	10-	e142W	MPC14752
Jan 13	11 50-63	Myrrha	13.5	2.565	95912	1.9	A0	6 34.8	16 27	11.6	8	21	30	-113 -7	-179 19	79 25	165	163	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	129 17	50 35	164	176	2-	none	Goffin88
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-	none	Goffin88
Jan 15	2 0- 1	Ida	15.4	3.196		10.1		23 30.2	-2 26	5.3	1	111	40	-128 58	-128 58	-102 65	58	68	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+	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+	w 51W	Goffin88
Jan 18	0 3- 4	Interamnia	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+	w 64W	Schmadel
Jan 19	1 31-44	Herculina	9.3	1.652		10.6		6 27.1	21 53	0.3	18	21	11	-6-42	-44-14	-102 5	158	124	9+	w 76W	Goffin88
Jan 19	5 9-23	Kleopatra	10.5	1.567	115296	9.1	G5	7 18.0	1 11	1.7	13	23	17	-11 31	-65 40	-154 54	158	134	10+	w142W	Goffin89
Jan 19	11 8-22	Patientia	11.7	2.325		11.2		3 19.1	11 39	1.0	26	34	15	116 4	126 32	-176 71	112	73	11+	w137E	MPC15529
Jan 19	16 45-55	Thetis	12.1	1.894	94986	5.9	B2	5 52.0	19 44	6.2	9	27	30	126-53	88-36	36-28	149	108	13+	w 59E	Goffin87
Jan 21	4 26-35	Athamantis	11.6	1.872	156876	8.2	A3	11 43.7	-11 45	3.5	30	61	21	38 48	32 41	23 19	118	172	25+	none	MPC11508
Jan 23	10 4	Nemausa	12.8	3.177	146465	6.1	M0	22 59.9	-6 51	6.7	3	9	34	central Siberia?s			41	47	48+	all	Goffin87
Jan 26	4 19-36	Circe	11.6	1.442		10.1		8 39.9	10 26	1.7	12	23	18	15 14	-38 34	-138 51	171	61	78+	w 19W	MPC13294
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 62	149	19	83+	all	Goffin88
Jan 28	1 54-55	Nepythys	13.0	2.980	146799	7.4	F5	23 33.4	-9 3	5.7	2	8	62	-111 27	-111 27	-89 33	44	107	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	100+	all	EMP 1987
Jan 31	21 58-76	Ariadne	12.1	1.651	157542	8.8	F5	12 48.0	-10 18	3.4	10	41	37	19 0	45-17	76-48	116	42	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	89-	e106W	Yeomans
Feb 2	9 60-90	Astraea	9.6	1.208	96089	6.8	B9	6 43.4	18 54	2.9	24	41	14	-129-47	-173-17	124 13	148	73	87-	e153E	Goffin86
Feb 3	3 43-66	Hermione	12.7	2.682		12.1		5 40.2	27 17	1.1	47	70	18	-5 43	-42 61	-164 70	132	99	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 -8	176	74	66-	e 1W	MPC15528
Feb 5	17 29-46	Lucina	12.3	2.000		12.5		13 28.8	9 10	0.7	21	41	21	108-37	136-22	174 6	117	30	58-	all	MPC15384
Feb 5	22 33-34	Juewa	13.6	3.422	92170	8.5	G5	0 54.1	11 26	5.1	6	13	30	-58 18	-48 20	-16 19	61	158	56-	none	MPC12303
Feb 10	7 46-67	Thetis	12.4	2.086		10.5		5 42.2	20 33	2.1	29	89	33	-163-52	-173-37	164-10	125	173	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	16	18	-150 47	-133 36	-104 15	99	109	1+	none	MPC11620
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	88	36+	w 71E	MPC14753
Feb 21	17 56-63	Mars	0.4	1.143	76660	9.1	A2	4 31.8	24 9		467	15	1	6 37	42 37	96 23	98	11	48+	all	NAO001
Feb 22	22 32-36	Carlova	12.8	2.120	94367	8.3	F8	5 7.8	15 13	4.5	9	22	25	-57 52	-33 62	50 65	104	11	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	12	28	-90-13	-71-17	-32-26	82	92	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	-18 58	123	71	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	-27-28	2-29	105	102	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	-26 20	-26 20	-9 19	48	79	79-	all	MPC12189
Mar 6	9 58-60	Ligura	14.3	3.632	210241	8.1	K2	18 27.1	-31 0	6.3	5	15	39	-132-27	-116-37	-86-52	69	43	69-	all	MPC14160
Mar 7	20 5-15	Pallas	6.7	1.240	137817	8.5	K0	10 47.3	-2 26	0.2	31	13	3	41-73	31-11	-21 42	170	85	56-	e 37E	Goffin87
Mar 8	8 17-31	Gyptis	12.5	2.284	138528	9.0	F0	11 58.1	-4 51	3.6	12	21	19	-50-24	-108 0	172 35	165	74	51-	e126W	MPC14930
Mar 11	18 58-85	Eunomia	9.7	1.941		10.7		8 18.6	11 59	0.4	70	70	10	91-41	55-36	0-36	134	169	20-	none	Goffin87

W(est) of Greenwich, preceded by a letter w(est) or e(ast) to specify the direction in which the Moon will be above the horizon. "All" or "none" is used to specify whether the Moon is up, or not, respectively, along the entire possible path if it is not crossed by the moonrise or moonset terminator. The source for the occulting body's ephemeris is given in the last column. For asteroids and comets, I have generated the ephemerides by numerically integrating the orbital elements given in the specified source. For the major planets, NA0001 is a U.S. Naval Observatory data set, used for Venus through Uranus. The other planets are obtained by my n-body integration of a Jet Propulsion Laboratory (JPL) Development Ephemeris #130 (DE130) solar system state provided by Doug Mink at the Center for Astrophysics in Cambridge, MA. The orbital elements by the late Paul Herget have been published in the Minor Planet

Table 2 part A

1991	M I N O R	P L A N E T					Motion		S T A R		Min.	Geocentric			Comparison Data			A P P A R E N T	
Date	No.	Name	km-Diam.	-//	RSOI	Type	°/Day	P.A.	SAO No	DM/ID No	D	U. T.	Sep.	S	AGK3 No	Shift	Time	R.A.	Dec.
Jan 1	146	Lucina	140	0.08	560	C	0.257	94°.9		+ 8°2676		$22^{h}10^{m}.8$	0".58N	MA	N 8°1620	0".01	$-1^{m}.3$	$13^{h}\ 5^{m}.3$	8°14'
Jan 3	121	Hermione	217	0.12	1393	C	0.184	276.9				19 34.3	2.19S	C				6 0.2	26 56
Jan 4	4	Vesta	560	0.40	4389	V	0.067	352.3	93228	+10 399		0 15.2	0.91W	UM	N10 317	0.26	0.9	2 59.6	10 37
Jan 5	532	Herculina	217	0.18	1078	S	0.272	297.3				13 23.2	1.58N	C				6 42.9	20 11
Jan 7	17	Thetis	93	0.07	323	S	0.234	278.7		A1946020		2 41.6	0.68S	C				6 5.5	19 17
Jan 9	121	Hermione	217	0.12	1396	C	0.169	276.1				10 50.2	1.38N	C				5 55.7	27 2
Jan 9	185	Eunike	165	0.12	771	C	0.177	306.0		+ 1 2287		13 44.6	1.35S	Ma	N 1 1191	0.27	1.1	9 21.1	1 6
Jan 9	19	Fortuna	171	0.18	641	G	0.191	270.1		A2144803		21 9.5	1.13S	C				5 50.2	20 56
Jan 10	46	Hestia	131	0.11	450	P	0.116	66.9				14 48.0	1.71N	C				3 0.3	14 1
Jan 10	11	Parthenope	162	0.13	709	S	0.252	286.7		L 4 3018		18 41.2	2.66N	H				7 53.4	19 25
Jan 11	184	Dejopeja	68	0.04	222	X	0.207	277.9	79496	+23 1747		17 10.7	2.50S	UM	N22 900	-0.10	0.9	7 32.7	22 52
Jan 12	110	Lydia	89	0.07	307	M	0.208	275.0	78343	+29 1217		13 14.8	0.06S	MX	N29 717	0.19	-1.2	6 24.9	29 35
Jan 13	381	Myrrha	124	0.07	627	C	0.196	287.9	95912	+16 1223		11 56.5	0.38N	FM		-0.06	0.0	6 37.2	16 24
Jan 14	532	Herculina	217	0.18	1071	S	0.257	298.7				15 0.7	0.11N	C				6 33.8	21 19
Jan 14	532	Herculina	217	0.18	1071	S	0.257	298.7				17 54.8	3.65S	C				6 33.7	21 20
Jan 15	243	Ida	33	0.01	69	S	0.339	66.7		B5432207		1 58.5	1.98N	C				23 32.3	-2 13
Jan 17	11	Parthenope	162	0.13	710	S	0.255	286.4		L 4 2579		21 19.4	3.77S	H				7 46.0	19 56
Jan 17	532	Herculina	217	0.18	1068	S	0.246	299.6		+21 1270		22 56.6	2.00S	MX	N21 682	0.05	0.0	6 30.6	21 44
Jan 18	704	Interamnia	333	0.16	2046	F	0.382	76.1				0 0.9	0.80S	C				23 29.7	13 24
Jan 19	532	Herculina	217	0.18	1067	S	0.241	300.0		L 1 954		1 37.7	2.72S	H				6 29.6	21 52
Jan 19	216	Kleopatra	137	0.12	518	M	0.225	282.3	115296	+ 1 1778		5 15.7	3.78N	Ma	N 1 881	-0.22	0.6	7 20.2	1 7
Jan 19	451	Patientia	230	0.14	1278	CU	0.125	22.4				11 10.5	0.32N	C				3 21.4	11 48
Jan 19	17	Thetis	93	0.07	322	S	0.179	282.0	94986	+19 1126	U	16 51.1	3.60S	3M	N19 500	0.10	1.3	5 54.5	19 45
Jan 21	230	Athamantis	130	0.10	476	S	0.078	171.3	156876	-11 3176		4 44.2	2.88E	UP		0.08	5.7	11 45.8	-11 59
Jan 23	51	Nemausa	137	0.06	521	CU	0.417	71.7	146465	- 7 5913		10 4.1	3.55N	UZ		-0.24	-0.1	23 2.1	-6 37
Jan 26	34	Circe	118	0.11	400	C	0.232	289.4		L 1 4514		4 27.6	3.06N	H				8 42.1	10 18
Jan 26	532	Herculina	217	0.18	1062	S	0.204	303.9				15 43.2	1.98N	C				6 23.4	22 45
Jan 28	287	Nephthys	70	0.03	179	S	0.447	67.8	146799	- 9 6220		1 52.1	0.73N	UZ		-0.32	-0.2	23 35.5	-8 49
Jan 30	27	Euterpe	118	0.16	332	S	0.255	289.9		+19 2138		2 52.4	5.14S	MX	N19 929	-0.25	-0.4	8 59.8	18 58
Jan 31	43	Ariadne	65	0.05	153	S	0.125	129.0	157542	- 9 3566		22 11.3	2.97S	U7		0.50	0.3	12 50.1	-10 32
Feb 2	46	Hestia	131	0.09	458	P	0.242	71.8				3 8.6	2.19N	C				3 16.3	15 25
Feb 2	5	Astraea	125	0.14	379	S	0.143	304.0	96089	+18 1338	V	10 18.1	2.88S	UM	N18 640	-0.79	0.4	6 45.9	18 51
Feb 3	121	Hermione	217	0.11	1410	C	0.057	275.8				3 57.8	2.36N	C				5 42.8	27 18
Feb 4	201	Penelope	71	0.05	239	M	0.232	292.0		+14 2005		22 6.6	2.28S	HM	N13 903	0.07	-0.1	8 58.0	13 42
Feb 5	146	Lucina	140	0.10	556	C	0.112	54.9				17 43.6	0.75S	C				13 30.9	8 57
Feb 5	139	Juewa	164	0.07	830	CP	0.279	66.1	92170	+10 110		22 30.3	0.24S	UX	N11 88	0.15	0.1	0 56.3	11 40
Feb 10	17	Thetis	93	0.06	321	S	0.051	318.6		A2143855		8 11.1	2.44S	C				5 44.7	20 34
Feb 15	187	Lamberta	135	0.11	426	C	0.318	120.4	158961	-15 4007		12 54.7	2.72N	UX		0.01	-0.7	14 59.9	-16 31
Feb 20	185	Eunike	165	0.12	785	C	0.255	317.6		L 1 4701		17 22.2	2.28S	H				8 48.9	7 57
Feb 21		Mars	6782	8.18			0.421	82.6	76660	+23 710		17 55.6	1.78N	UR	N24 416	-0.04	-0.1	4 34.3	24 14
Feb 22	360	Carlova	121	0.08	437	C	0.203	55.9	94367	+15 755		22 29.2	2.19N	UM	N15 448	-0.13	-0.3	5 10.2	15 16
Mar 1	404	Arsinoe	101	0.07	273	C	0.390	96.2	160372	-12 4686		7 13.8	1.33S	UP		-0.56	0.3	17 12.7	-12 43
Mar 2	216	Kleopatra	137	0.10	541	M	0.102	17.5				1 19.0	0.79S	C				7 2.3	4 44
Mar 2	17	Thetis	93	0.06	319	S	0.105	69.9		A2143457		23 0.5	3.12S	C				5 47.7	21 20
Mar 5	56	Melete	117	0.06	328	P	0.559	76.8		L 5 1476		6 20.3	2.15N	H				19 51.1	-14 34
Mar 6	356	Ligura	135	0.05	688	C	0.229	94.7	210241	C3115599		10 1.8	1.24S	HS		0.45	-1.1	18 29.8	-30 58
Mar 7	2	Pallas	533	0.59	3526	B	0.464	338.5	137817	- 1 2450		20 9.8	2.91S	UM	S 2 622	0.50	-0.1	10 49.5	-2 39
Mar 8	444	Gyptis	170	0.10	928	C	0.207	301.5	138528	- 4 3181		8 23.8	0.38N	UR		0.01	0.0	12 0.2	-5 5
Mar 11	15	Eunomia	272	0.19	1573	S	0.067	269.9				19 15.4	3.29S	C				8 20.9	11 51

Circulars (MPC's) numbered 4360–4390 (1978 June), 4736–4739 (1979 June), 4824–4825 (1979 August), and 6190–6191 (1981 August). EMP stands for the Leningrad Ephemerides of Minor Planets. For some objects, orbital elements by Kristensen (University of Aarhus, Denmark), Landgraf (then at the Max-Planck Institut für Aeronomie, Lindau, Germany), Marsden (Minor Planet Center, Cambridge, MA), Schmadel (Astronomisches Rechen-Institut, Heidelberg, Germany), Sitarsky (Poland), and Yeomans (JPL) have been used. One of the most important columns in the table is Δm, since it specifies the observability of the

Table 1 part B

1991 Date	Universal Time	PLANET Name	PLANET m_v	PLANET Δ,AU	STAR SAO NO	STAR m_v	STAR Sp	STAR R.A. (1950)	STAR Dec.	Occultation Δm	Occultation dur	Occultation df	Occultation P	Possible Path LolLal	Possible Path LomLam	Possible Path LoeLae	El Sun	MOON El	MOON %Snl	MOON Up	Ephem. Source
Mar 13	7h51–64m	Lucina	11.7	1.680		12.4		13h25m.4	12°35'	0.5	16s	9	17	-37°22°	-63°46°	162°78°	150°	118°	10-	e 50W	MPC15384
Mar 16	1 13-20	Aeria	12.8	1.962		11.9	G5	10 53.5	26 3	1.3	5	23	46	62 41	44 55	-2 81	154	153	0-	none	MPC14160
Mar 17	2 42-43	Chicago	13.9	4.037	162723	7.2	K2	19 28.8	-19 30	6.7	6	14	34	-6-13	3-16	34-22	65	74	1+	none	MPC11724
Mar 17	11 46-46	Davida	11.5	3.285		11.1		2 41.6	4 50	1.0	8	9	14	109-24	109-24	123-22	45	33	2+	none	MPC15384
Mar 18	8 35-38	Fortuna	11.4	2.040		9.3		6 4.5	21 39	2.2	10	17	17	-175 71	-144 65	-113 55	94	69	5+	w158W	MPC13923
Mar 20	20 16-20	Hermione	13.3	3.355		13.1		5 51.6	27 27	0.9	14	23	22	-5 46	18 40	48 27	89	31	24+	w 38E	MPC12191
Mar 24	14 29-33	Herculina	10.2	2.214		11.7		6 27.9	27 22	0.2	15	20	15	79 59	112 57	151 46	93	15	65+	all	Goffin88
Mar 24	16 55-92	Ekard	13.7	2.171	183265	8.9	G5	15 9.9	-23 3	4.8	22	68	34	176-46	131 -9	86 35	131	119	66+	w124E	EMP 1986
Mar 24	23 9-12	Carlova	13.2	2.534		10.5		5 37.5	18 15	2.8	5	13	30	-63-27	-49-25	-20-27	81	31	69+	all	MPC14754
Mar 26	0 42-53	Winchester	12.7	2.487		10.4	K0	12 5.3	19 55	2.5	12	20	20	31-40	-17 -8	-87 6	158	46	80+	w 22E	Landgraf
Mar 27	14 11-28	Lamberta	11.0	1.290	183474	8.7	K0	15 23.8	-22 20	2.5	25	42	14	(P.I.,W.Australia)?e			131	82	92+	all	MPC11620
Mar 27	21 34-39	Diotima	12.5	2.620		10.8		17 38.5	-22 36	1.9	19	28	18	77 43	92 34	113 23	101	109	93+	w 99E	MPC12305
Mar 28	0 27-29	Metis	10.3	1.687	79974A	6.9	K0	8 5.8	27 38	3.5	23	31	13	(Chile, Argentina)?n			111	41	94+	all	MPC11234
Mar 28	0 21-32	Metis	10.3	1.687	79974B	10.4		8 5.8	27 38	0.7	23	31	13	-80 0	-59-12	-31-35	111	41	94+	all	MPC11234
Mar 28	16 55-72	Urania	11.1	1.622	118734	6.8	F2	11 11.3	2 32	4.3	10	23	23	170 3	115 17	31 45	161	2	97+	all	MPC12680
Mar 30	5 51-61	Pallas	7.3	1.346	118404	9.0	G5	10 35.7	6 45	0.2	36	15	4	-44-27	-68 5	-41 51	150	30	100+	all	Goffin87
Mar 31	23 44-61	Aegle	11.3	1.690	156875	9.2	K5	11 43.3	-17 54	2.2	16	23	14	78-21	10-31	-75-12	161	29	97-	all	MPC16843
Apr 1	3 11	Hestia	13.7	2.836	94021	8.0	F8	4 32.7	19 52	5.7	4	10	31	-89 70	-89 70	-63 64	59	142	96-	e 75W	Yeomans
Apr 2	21 8-20	Hektor	14.6	4.189	181911	8.2	K0	13 41.1	-28 25	6.4	15	26	26	125-22	56-37	-30-12	153	23	87-	e 21W	EMP 1975
Apr 3	12 31-32	Carlova	13.3	2.666		10.5		5 50.0	19 0	2.9	5	12	32	115 59	130 58	157 52	75	153	83-	none	MPC14754
Apr 4	10 8- 9	Carlova	13.3	2.679		9.5		5 51.2	19 3	3.8	5	12	32	149 48	162 47	-172 42	74	163	76-	none	MPC14754
Apr 4	16 22	Melete	12.5	2.275	164000	8.9	F5	20 54.2	-10 7	3.6	3	8	28	160-55	160-55	-170-55	61	58	74-	all	MPC12189
Apr 4	18 39-41	Venus	-4.0	1.230	93319	7.9	K0	3 7.9	18 33		276	5	1	e.&cen. Europe, Libya			36	153	73-	none	NA0001
Apr 5	1 15-17	Thetis	13.1	2.759		10.7		6 10.9	22 18	2.5	4	16	43	-78 54	-64 52	-30 42	78	167	70-	none	Goffin87
Apr 5	20 1- 2	Psyche	11.4	3.075	77145	9.0	F2	5 21.2	20 58	2.5	9	12	17	-10 19	0 17	29 8	66	171	64-	none	Goffin87
Apr 7	1 50-54	Herculina	10.3	2.366		11.8		6 42.6	27 53	0.2	11	16	16	-97 37	-73 33	-42 22	83	174	52-	none	Goffin88
Apr 8	2 1- 5	Dejopeja	13.9	2.834		12.1		7 16.2	22 49	2.0	4	21	60	-101 0	-83 -6	-57-17	90	172	43-	none	EMP 1983
Apr 8	23 45-47	Herculina	10.3	2.387		10.9		6 45.0	27 57	0.5	11	15	16	-43 62	-28 59	4 45	82	153	34-	none	Goffin88
Apr 9	18 42-43	Doris	12.4	3.094		11.0		5 54.5	17 29	1.7	8	13	20	14 28	25 27	46 22	70	132	27-	none	MPC12188
Apr 11	3 25-26	Vesta	8.4	3.117		9.1	K0	4 29.8	20 2	0.5	16	10	8	-110 45	-110 45	-98 42	49	95	16-	none	Goffin86
Apr 11	18 23-24	Psyche	11.5	3.156		10.1		5 29.3	21 10	1.6	8	11	17	10 21	21 19	41 14	62	101	11-	none	Goffin87
Apr 12	0 36	Patientia	12.4	3.394	76692	8.3	F5	4 36.7	21 25	4.1	6	10	21	(Chile, Peru)?n			50	85	10-	none	MPC15529
Apr 13	19 7- 9	Fortuna	11.8	2.410		10.5		6 39.8	21 34	1.6	7	12	20	18 53	29 50	59 39	76	90	2-	none	MPC13923
Apr 15	10 41-42	Anahita	12.5	1.768		10.6		19 42.9	-20 50	2.1	3	13	49	-118 36	-112 34	-93 34	90	99	1+	none	MPC16844
Apr 16	1 19-30	Ursula	12.1	2.252	205100	10.5		13 58.4	-33 5	1.9	16	22	15	38 23	-6 7	-66 23	156	165	2+	none	MPC16385
Apr 23	20 28-31	Xanthippe	13.3	2.374	144968A	5.7	K2	20 54.2	-9 53	7.6	5	13	27	75 8	98 9	128 20	80	161	75+	w 83E	EMP 1986
Apr 23	20 29-31	Xanthippe	13.3	2.374	144968B	11.7		20 54.2	-9 53	1.9	5	13	27	(cen.Siberia,n.China)?s			80	161	75+	w 89E	EMP 1986
Apr 26	1 59-60	Patientia	12.4	3.534		11.3		4 58.0	22 42	1.4	6	9	22	Baffin Is., Greenland			41	106	92+	all	MPC15529
Apr 28	9 54-101	Eros	11.5	0.616	227542A	6.4	G9	16 56.7	-48 34	5.1	6	41	39	-69 3	-122-26	159 -3	132	49	100+	all	EMP 1985
Apr 28	9 55-100	Eros	11.5	0.616	227542B	7.5	G	16 56.7	-48 34	4.1	6	41	39	-73 6	-123-22	162 0	132	49	100+	all	EMP 1985
May 2	6 51	Doris	12.6	3.369		11.9		6 24.1	17 59	1.1	6	11	22	173-36	173-36	-171-40	55	161	89-	e178W	MPC12188
May 2	19 31	Fortuna	12.0	2.665	79169	8.7	F5	7 9.7	21 3	3.3	6	10	23	23 58	32 54	49 47	65	159	86-	none	MPC13923
May 3	8 55	Doris	12.6	3.382		9.7		6 25.7	17 59	3.0	6	11	22	140-38	140-38	155-43	54	172	82-	none	MPC12188
May 5	11 2- 6	Eunomia	10.7	2.712	98056	9.0	G5	8 39.5	10 37	2.0	15	18	14	117 -8	135-14	174-25	86	165	65-	e174E	Goffin87
May 5	12 30	Venus	-4.1	1.018	77437	9.0	B3	5 39.7	25 42		352	6	1	100 20	100 20	119 12	42	148	65-	none	NA0001
May 6	18 37-43	Eugenia	11.6	1.951		11.4	F5	11 3.4	11 34	0.9	63	82	13	87 63	91 60	103 52	117	149	53-	e 99E	MPC13294
May 7	20 9-12	Eunomia	10.7	2.748		12.6		8 41.6	10 29	0.2	14	17	15	-11 20	6 14	34 6	84	164	42-	none	Goffin87
May 9	4 3	Venus	-4.1	0.991	77838	9.1	K7	5 58.0	25 53		364	6	1	-149-23	-149-23	-142-26	42	107	29-	none	NA0001
May 10	7 8-12	Euterpe	11.3	1.958		10.2	G5	9 19.2	17 22	1.5	6	14	24	-178 26	-160 18	-124 1	88	140	19-	none	EMP 1987

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_v 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 Δm may be much larger than the given value. I plan to correct this problem with a future star catalog update. A Δm 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 Δm'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		MINOR PLANET					Motion		STAR			Min.	Geocentric		Comparison Data			APPARENT	
Date	No.	Name	km-Diam.	-//	RSOI	Type	°/Day	P.A.	SAO No	DM/ID No	D	U. T.	Sep.	S	AGK3 No	Shift	Time	R.A.	Dec.
Mar 13	146	Lucina	140	0.11	552	C	0.176	$308^\circ.5$				$7^h55^m.4$	$3''.26$N	C				$13^h27^m.5$	12°22'
Mar 16	369	Aeria	62	0.04	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	81.4	162723	-19 5492		2 45.7	0.10S	UZ		$0''.23$	$-0^m.5$	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	G	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				6 30.5	27 21
Mar 24	694	Ekard	93	0.06	338	CP:	0.066	319.2	183265	C2210887		17 7.3	0.23S	UX		0.10	2.5	15 12.4	-23 12
Mar 24	360	Carlova	121	0.07	443	C	0.307	74.3		A1843076		23 9.0	2.62S	C				5 39.9	18 16
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 41
Mar 27	187	Lamberta	135	0.14	422	C	0.137	175.1	183474	C2210999		14 20.3	7.04W	UX		0.37	0.9	15 26.3	-22 29
Mar 27	423	Diotima	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 887	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 887	0.28	0.1	8 8.3	27 30
Mar 28	30	Urania	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	3588	B	0.368	349.0	118404	+ 7 2339		5 56.0	4.80E	UM	N 6 1336	-0.20	0.0	10 37.9	6 32
Mar 31	96	Aegle	174	0.14	785	U	0.217	278.7	156875	-17 3465		23 52.9	1.00S	S				11 45.4	-18 8
Apr 1	46	Hestia	131	0.06	479	P	0.392	80.6	94021	+19 740		3 9.7	2.48N	UR	N19 359	-0.03	0.0	4 35.2	19 57
Apr 2	624	Hektor	234	0.08	2351	D	0.123	270.0	181911	C2810228		21 13.5	0.33S	PS		0.04	2.8	13 43.5	-28 38
Apr 3	360	Carlova	121	0.06	445	C	0.330	77.7		A1944409		12 29.4	1.99N	C				5 52.4	19 0
Apr 4	360	Carlova	121	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	164000	-10 5551		16 24.0	2.20S	US		0.04	-0.7	20 56.4	-9 57
Apr 4		Venus	12220	13.70			1.191	71.8	93319	+18 424		18 38.5	7.39N	UX	N18 241	0.35	0.0	3 10.2	18 43
Apr 5	17	Thetis	93	0.05	316	S	0.250	85.6		L 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	0.316	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				1 48.5	0.61N	C				6 45.2	27 51
Apr 8	184	Dejopeja	68	0.03	218	X	0.181	99.7		A2355505		1 58.5	1.01S	C				7 18.7	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 416	-0.22	0.5	4 32.2	20 7
Apr 11	16	Psyche	264	0.12	1563	M	0.327	84.7		A2141271		18 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	G	0.348	92.9		A2251565		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	Ursula	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		0.67	0.1	20 56.4	-9 44
Apr 23	156	Xanthippe	126	0.07	438	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	227542	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	227542	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	48	Doris	219	0.09	1216	CG	0.337	88.7		A1849104		8 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	16.55			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	1038	FC	0.057	111.5		+12 2301		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 608	0.02	0.0	6 0.5	25 54
May 10	27	Euterpe	118	0.08	359	S	0.343	108.9		+17 2069		7 7.3	1.09N	Xa	N17 1020	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. Δm'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 Date	Universal Time	PLANET Name	PLANET m_v	PLANET ΔAU	STAR SAO NO	STAR m_v	STAR Sp	STAR R.A.(1950)	STAR Dec.	Occultation Δm	Occultation dur	Occultation df	Occultation P	Possible Path LolLal	Possible Path LomLam	Possible Path LoeLae	El Sun	MOON El	MOON %Snl	MOON N Up	Ephem. Source
May 11	10h46-47m	Thetis	13.3	3.176		10.3		6h58m.4	22°26'	3.0	3s	11	50	138°39°	138°39°	157°31°	54°	91°	10-	none	Goffin87
May 13	10 46-47	Fortuna	12.1	2.801		11.7		7 27.3	20 34	1.0	5	10	24	120-16	120-16	138-23	59	69	1-	none	MPC13923
May 15	4 32-33	Pandora	12.5	2.782	146879	9.2	G5	23 42.1	-6 10	3.3	2	10	59	-25-12	-15-12	13 -7	60	74	2+	none	MPC15524
May 18	20 14	Nemausa	12.7	3.405	110447	8.8	G0	2 14.2	9 33	4.0	3	8	36	141-29	9 0	141-29	23	86	28+	none	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+	all	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+	all	Goffin87
May 27	3 7-19	Rachele	12.2	2.371	184425	7.3	B9	16 26.9	-25 2	4.9	7	20	34	19 30	-45 9	-114 23	175	19	98+	w 14E	MPC16391
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	MPC16844
May 30	11 3- 6	Dunham	18.3	2.765		9.6		10 6.1	13 16	8.7	1	17	309	131 32	148 23	173 13	81	121	96-	e140E	EMP 1986
Jun 1	3 40	Hygiea	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-	all	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-	none	NA0001
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-	all	MPC12188
Jun 3	8 27	Carlova	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-	none	MPC14754
Jun 5	21 33-34	Chiron	15.6	11.087		9.6	F5	7 40.7	14 52	6.0	6	21	80	-47-18	-47-18	-38-21	41	128	48-	none	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-	none	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	106 16	105	82	4-	e 88E	Goffin86
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	68	2-	none	NA0001
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-	none	EMP 1986
Jun 11	14 9-26	Eros	11.5	0.649	226005	8.0	K2	15 34.8	-41 24	3.6	3	20	41	-152-14	163-12	133 33	152	161	1-	none	EMP 1985
Jun 13	12 20-36	Diotima	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	146071	9.3	F8	22 21.7	-6 28	0.9	15	21	13	53 41	71 40	98 39	107	126	3+	none	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	MPC14160
Jun 16	5 15-38	Elektra	11.7	2.175	143734	8.7	A0	19 41.1	-0 6	3.1	23	35	17	3 -1	-58-11	-132-20	141	154	19+	w121W	MPC14159
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+	none	MPC12188
Jun 17	13 2- 3	Dunham	18.5	2.997		11.4		10 24.3	11 31	7.1	0	13	334	84-22	93-26	113-34	68	5	32+	all	EMP 1986
Jun 19	8 38	Venus	-4.3	0.663	98329	8.4	G5	9 1.0	18 53		666	9	1	eastern Australia			45	48	52+	sll	NA0001
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+	none	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	Antarctic?n, S.Af.?2"n			136	66	97+	all	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	6	98+	all	EMP 1989
Jun 26	3 59-62	Daphne	13.5	3.288	109714	8.9	K2	1 8.0	6 29	4.6	9	17	26	-30-32	-9-29	28-21	75	115	99+	all	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-	all	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-	all	Landgraf
Jul 2	1 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-	all	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	70 -9	9-29	-82-53	155	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	128 0	79-21	0-27	146	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-	all	MPC11982
Jul 9	7 26-44	Ate	13.1	1.888	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	MPC15526
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-	none	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-	none	NA0001
Jul 12	7 31-42	Ligura	13.1	2.336		9.8	F0	18 15.4	-34 49	3.4	10	22	25	-27-43	-90-68	150-46	161	154	0+	none	MPC14160
Jul 13	8 4-39	Anahita	10.4	0.919		10.4		20 29.7	-15 31	0.8	9	35	26	-46 5	-108 -5	178 1	164	174	4+	none	MPC16844
Jul 15	14 33-42	Tercidina	12.8	1.867		10.1	G0	0 10.6	11 27	2.8	10	26	27	154-32	-177-17	-145 3	105	157	20+	none	MPC13442
Jul 23	3 54-57	Ceres	8.7	2.555		11.6		13 47.0	-4 45	0.07	48	16	4	-118 33	-101 21	-76 13	87	54	89+	all	MPC12187
Jul 23	6 51	Dunham	18.6	3.387		11.6		11 7.9	7 5	7.0	0	10	378	-168 19	-168 19	-160 17	46	96	89+	all	EMP 1986
Jul 23	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+	none	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	MPC11982
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+	all	DE130
Jul 27	18 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-	all	MPC12190

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	MINOR PLANET No.	Name	km-Diam.	"	RSOI	Type	Motion °/Day	P.A.	STAR SAO No	DM/ID No	D	Min. U.T.	Geocentric Sep.	S	Comparison Data AGK3 No	Shift	Time	APPARENT R.A.	Dec.
May 11	17	Thetis	93	0.04	313	S	0.343	92°9		L 1 2237		$10^h44^m.1$	1"34N	H				$7^h 0^m.9$	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	$-0^m.3$	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	−0.2	2 16.4	9 45
May 21	48	Doris	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	Rachele	101	0.06	442	S	0.214	265.6	184425	C2412694		3 12.9	2.09N	YG		−1.78	1.5	16 29.5	−25 8
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	10	Hygiea	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	16 51
Jun 3		Venus	12220	21.24			1.023	102.7	79847	+23 1863		7 18.2	16.79N	UR	N23 901	−0.16	0.0	7 59.2	23 12
Jun 3	25	Phocaea	73	0.08	144	S	0.419	32.5	106792	+15 4317		8 15.3	1.27N	MR	N15 2333	0.00	0.3	21 2.4	15 56
Jun 3	360	Carlova	121	0.05	460	C	0.406	93.1		A2156413		8 25.3	0.96S	C				7 29.6	20 30
Jun 5	2060	Chiron	200	0.02	3767	B	0.095	96.3		L 4 2389		21 30.6	0.29S	H				7 43.1	14 46
Jun 9	146	Lucina	140	0.09	546	C	0.178	154.3				10 59.0	2.20N	C				12 42.9	10 6
Jun 10	6	Hebe	186	0.15	711	S	0.254	86.5	146041	− 6 5972		21 53.6	2.01N	UZ		−0.27	0.0	22 21.0	−6 17
Jun 11		Jupiter	140904	32.84			0.174	105.9	98207	+18 2076		6 19.1	14.26S	UX	N18 917	0.07	0.7	8 53.5	18 16
Jun 11	694	Ekard	93	0.07	309	CP:	0.151	322.0	158489	−12 4018	U	11 41.3	5.77S	F		−0.10	0.1	14 18.7	−13 20
Jun 11	433	Eros	23	0.05	23	S	0.401	325.4	226005	P41 7277		14 17.4	9.74N	PS		−0.47	0.1	15 37.6	−41 32
Jun 13	423	Diotima	217	0.15	1220	C	0.213	258.5	185272	C2612078		12 28.0	0.37S	UX		0.34	−0.2	17 19.5	−26 36
Jun 13	6	Hebe	186	0.16	709	S	0.242	88.5	146071	− 6 5984		21 9.3	3.81N	UX		−0.04	1.2	22 23.9	−6 15
Jun 15	356	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	−34 35
Jun 16	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	0 0
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	20 23
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	18 43
Jun 19	776	Berbericia	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	−15 35
Jun 20	65	Cybele	230	0.07	1630	P	0.275	75.0	93133	+13 456		9 20.4	1.11N	UM	N13 226	−0.31	0.7	2 49.7	13 41
Jun 25	53	Kalypso	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	−13 19
Jun 25	476	Hedwig	121	0.11	422	P	0.232	296.4	185342	C2913461		13 38.5	3.56N	XY		−1.22	1.8	17 22.7	−29 32
Jun 26	41	Daphnw	182	0.08	1008	C	0.207	79.9	109714	+ 5 150		4 4.1	1.11S	UM	N 6 115	0.25	0.1	1 10.1	6 42
Jun 29	65	Cybele	230	0.08	1633	P	0.261	76.0		+13 488		8 56.9	1.31N	MX	N14 268	−0.70	0.0	2 59.4	14 17
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	13 36
Jul 2	56	Melete	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	4 25
Jul 3	130	Elektra	189	0.13	1004	G	0.200	247.0	143525	− 1 3769		1 6.9	2.21S	MP	S 0 2485	−0.76	−0.7	19 32.8	−0 51
Jul 4	53	Kalypso	119	0.08	510	XC	0.135	247.8	164223	−14 5963		20 28.9	0.29S	UX		−0.43	−1.0	21 12.8	−13 43
Jul 7	20	Massalia	151	0.07	516	S	0.509	81.2	76609	+21 644	J	5 16.3	2.84S	Ua	N21 419	−0.37	−0.1	4 25.8	21 27
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	−18 16
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	16 35
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	Tercidina	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	Ceres	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	22 31
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	10 48
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	23 26

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

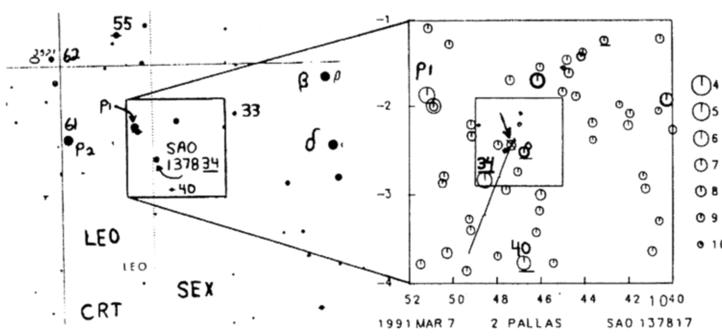
After RSOI, the taxonomic Type is given for asteroids, as specified in pages 1139 - 1150 of Asteroids II, using the types given by David Tholen in his 1984 Ph.D. dissertation and amended by him for the book. Most of the old classes mentioned in ON 4 (1), 7 have been retained, but several new classes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



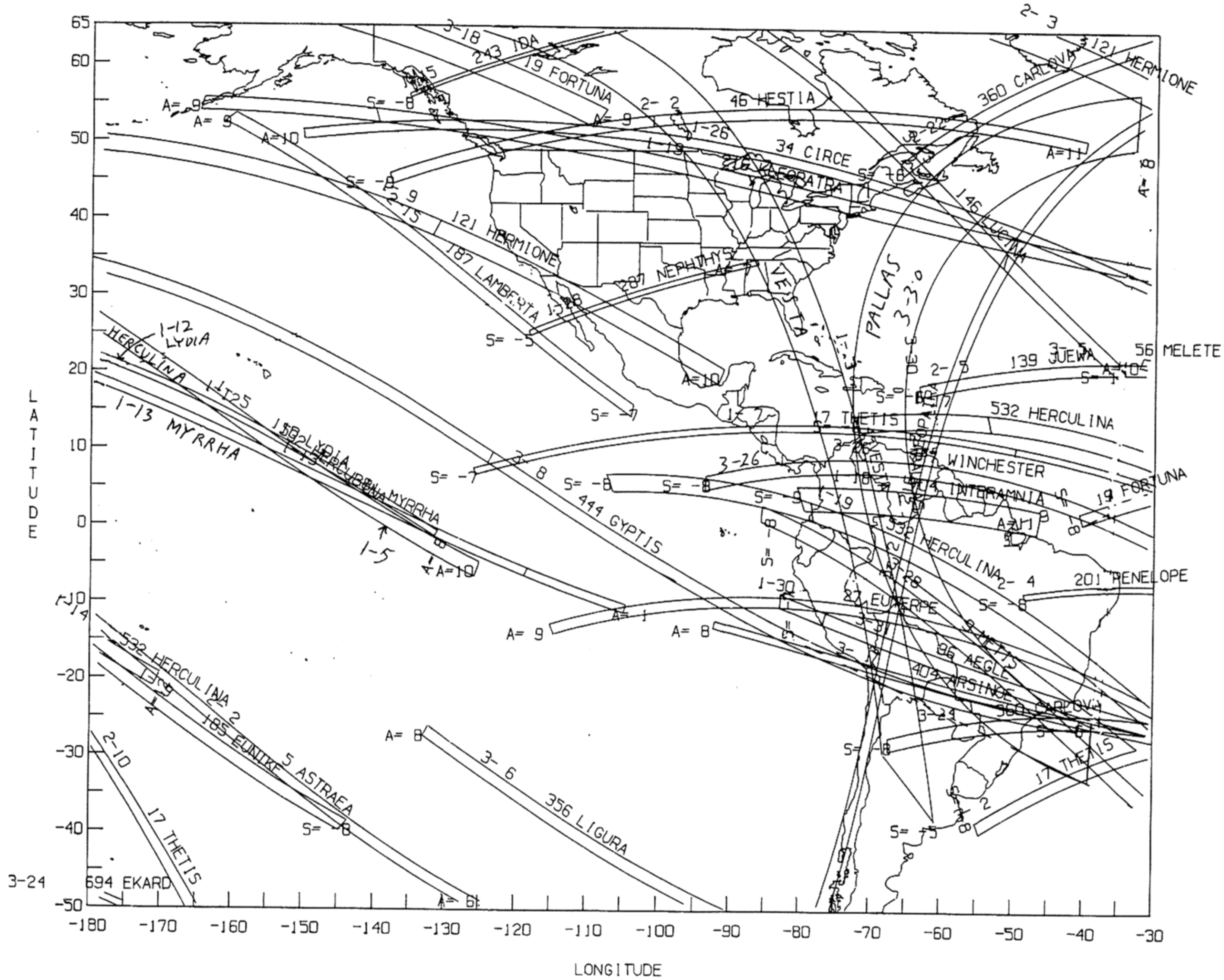
The star's Bonner Durchmusterung (BD) or Cordoba Durchmusterung (CD) declination zone and catalog numbers are given under the DM/Id No column, when available. The first character of the zone column identifies the catalog:

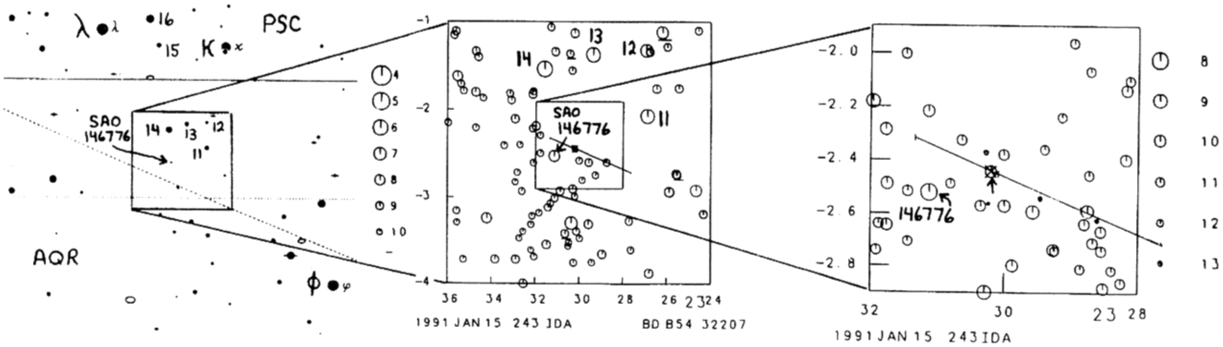
character	identification
+	BD (Bonner Durchmusterung)
-	BD (usually the southern part, sometimes called S.D.)
C	CD (Cordoba Durchmusterung; -)
P	Cape Photographic Durchmusterung (-)
L	Lick Voyager catalogs; the five Lick "zones" are given below; the number within the zone is sequential in 1950 R.A.
L 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)

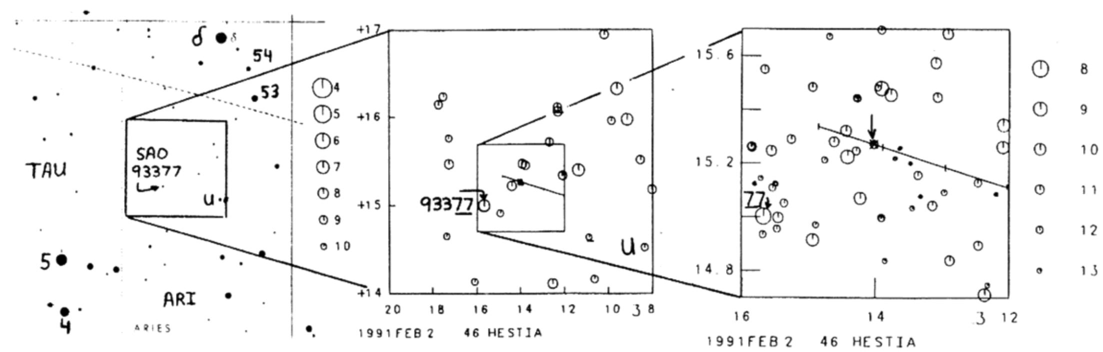
Following the star's numbers is the column D, the star's double star code. If separate predictions are given for the two components, "A" and "B" are used, "A" indicating the brighter component. Otherwise, the code is the same as that used for lunar occultation predictions as described in "Notice to Observers" 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.

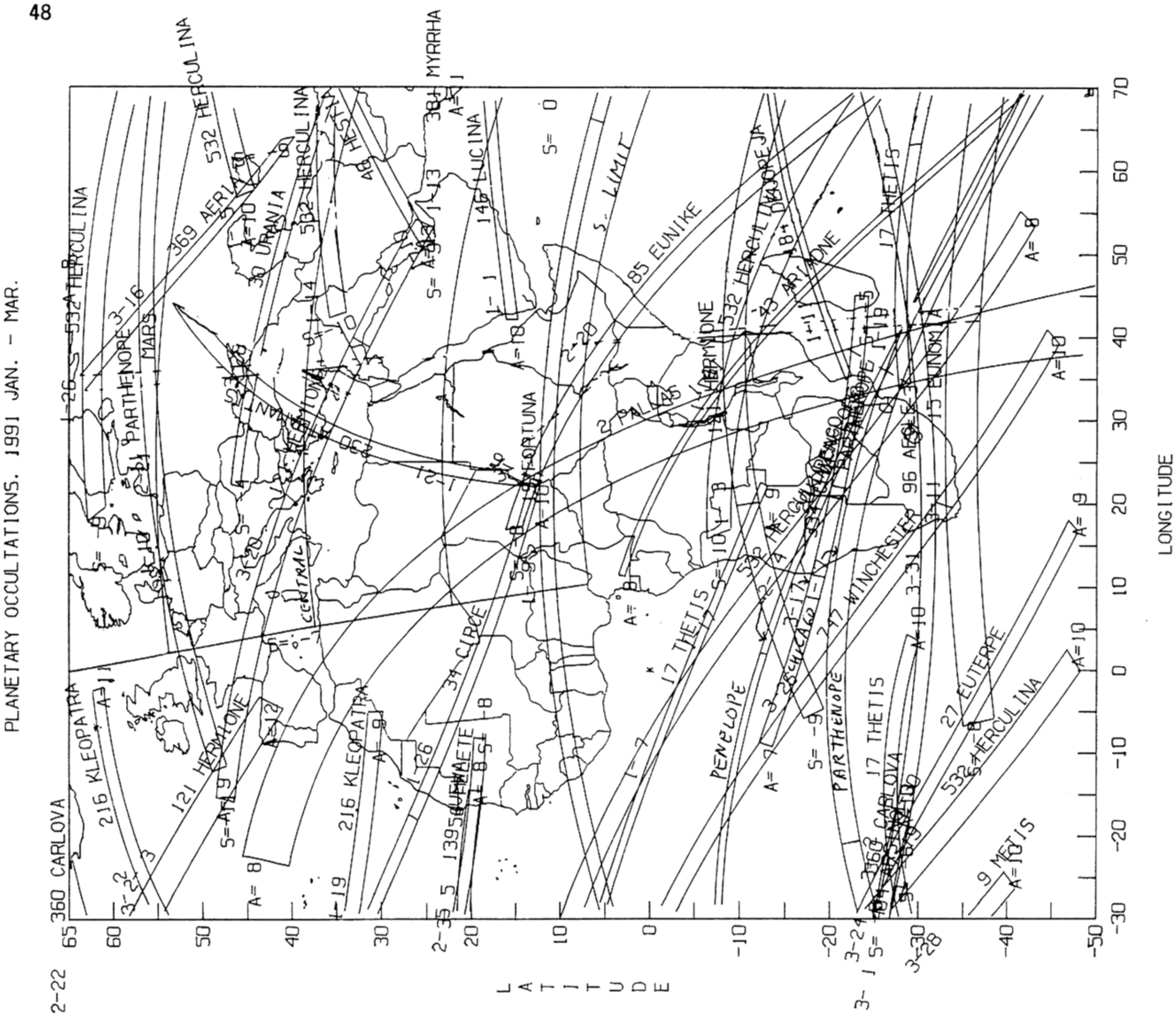
The geocentric Universal Time and distance of closest approach of the center of the planet to the star are given under the columns Min. Geocentric U. T. and Sep. Following the separation value is a letter indicating its direction, usually (N)orth or (S)outh. But when the motion is nearly due north-south, 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 "ΔAU" 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

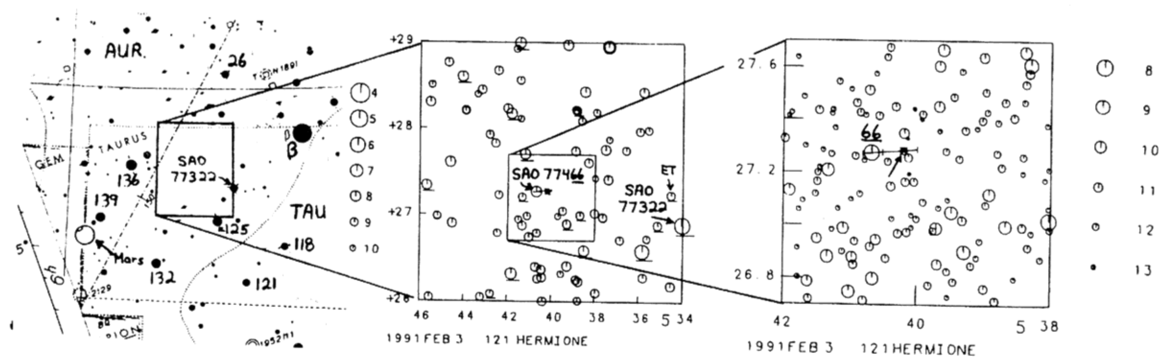
PLANETARY OCCULTATIONS. 1991 JAN. - MAR.



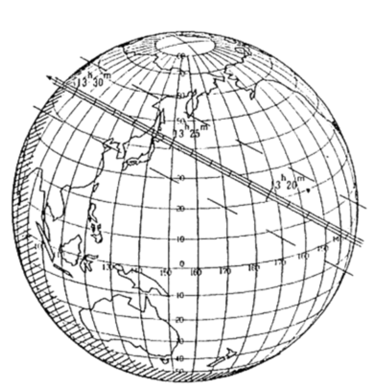






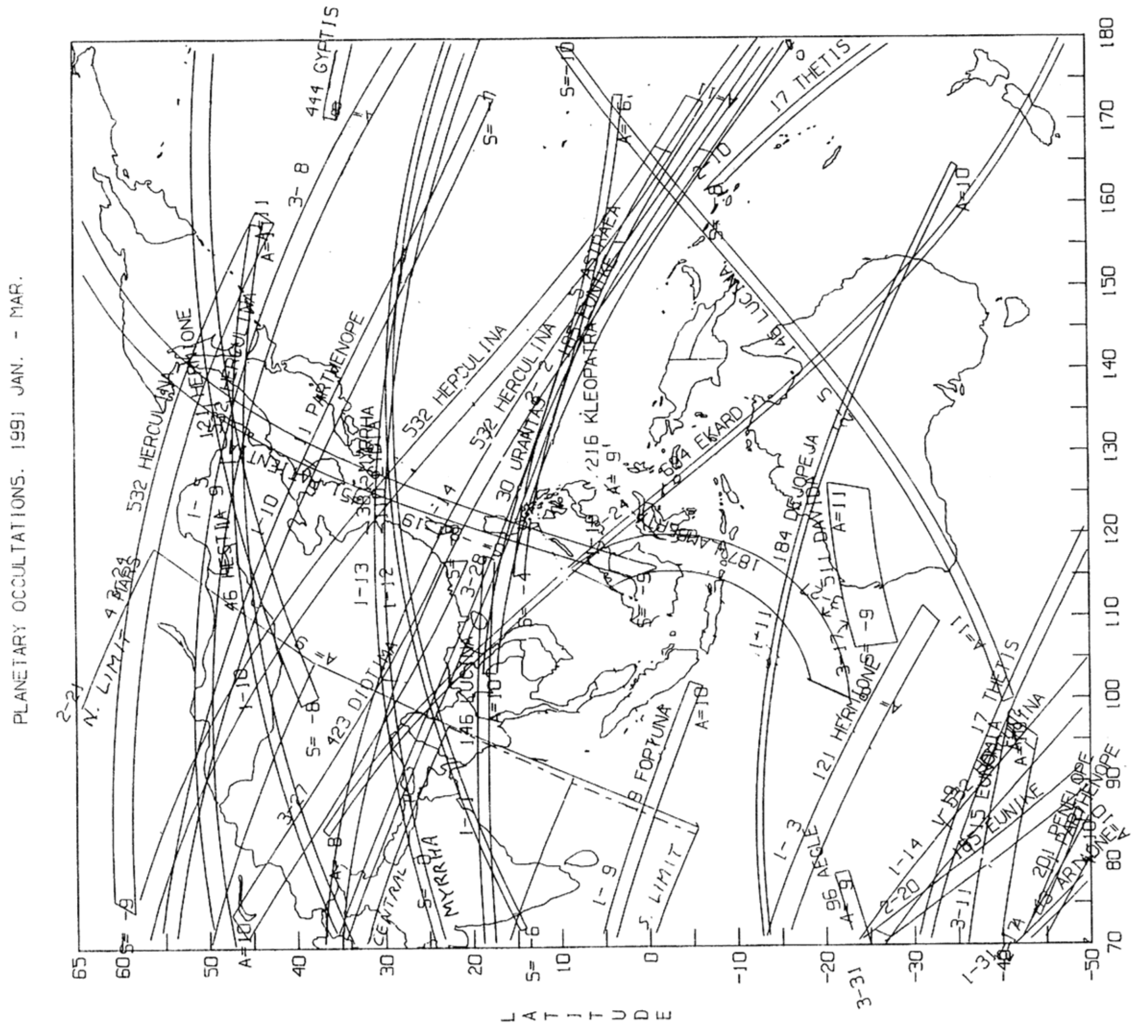


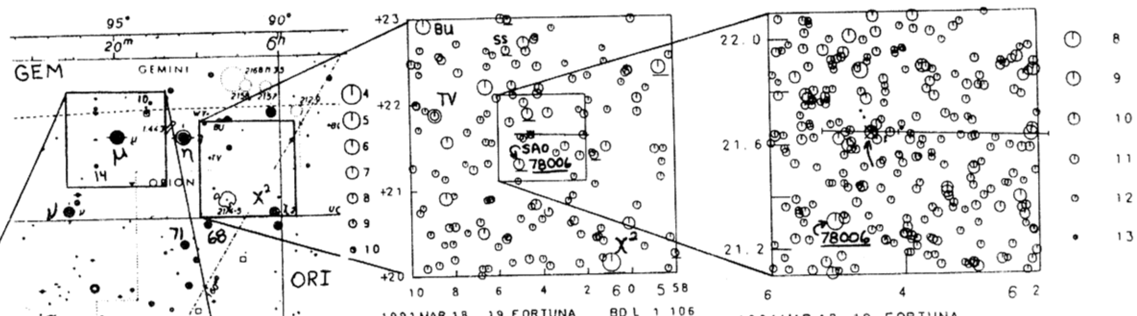
SAO 93228 by Vesta 1991 Jan 3-4

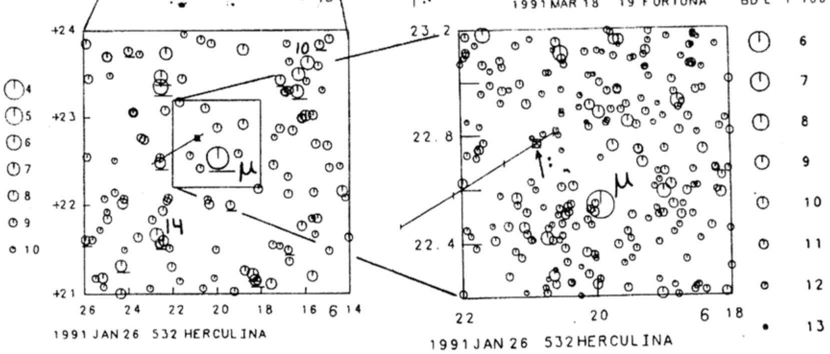


Anonymous by Herculina 91 Jan 5

A21°44803 by Fortuna 1991 Jan 9







Anonymous by Hestia 1991 Jan 10

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 predictions 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 annoted 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".0006.

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 Cancri = 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: Disappaeance 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.

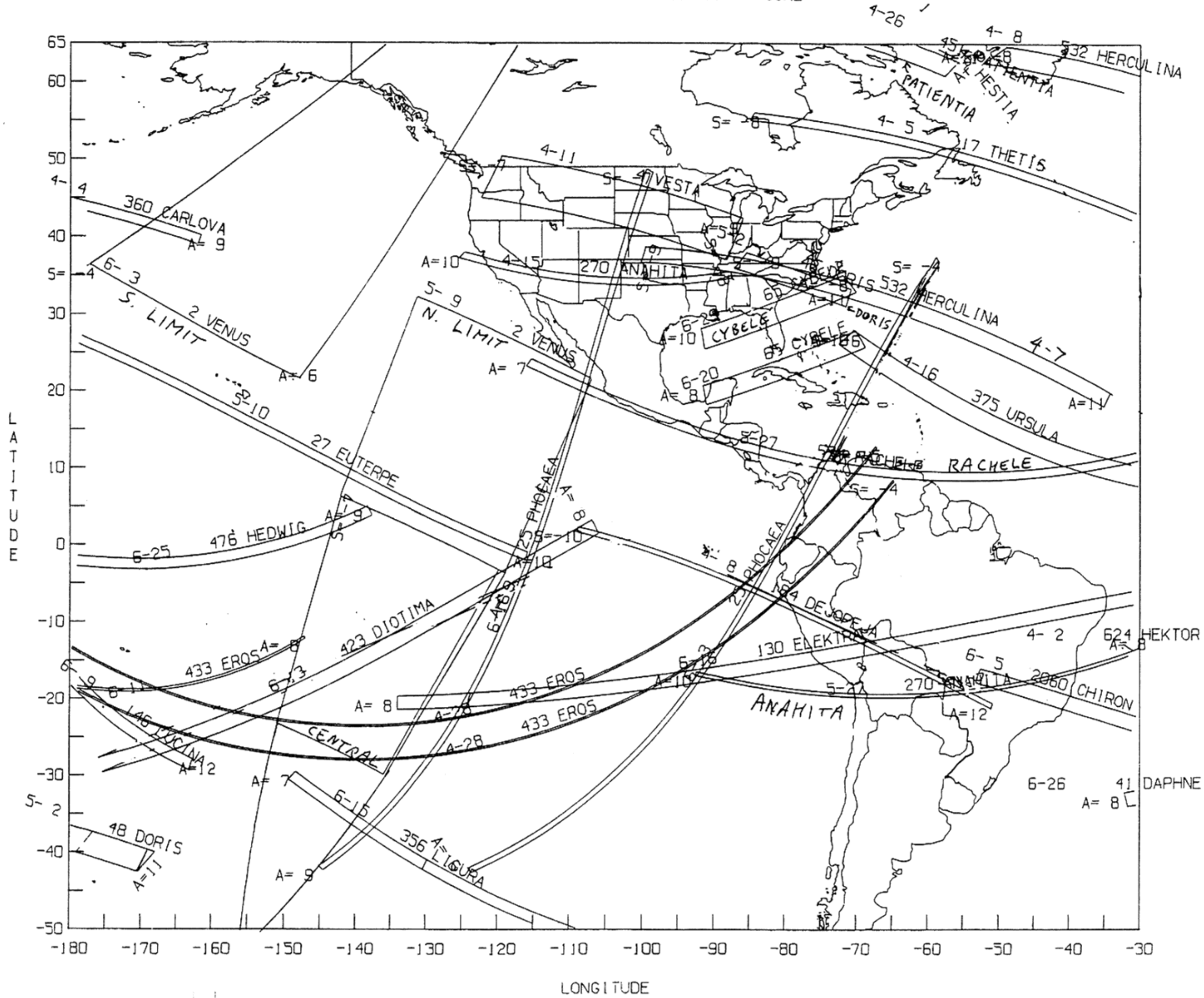
May 27, (674) Rachele: There was an error in the Yale proper motion in my combined catalog, corrected here. However, Goffin used the same catalog, and derived an incorrect path much farther south. Hence, Stamm sent data for the event to observers in S. America and southern Africa, but it might be visible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

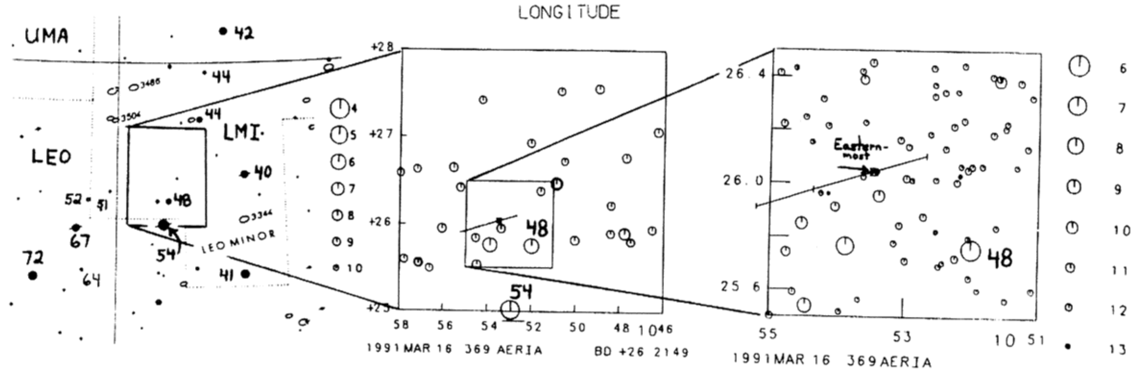
June 3, Venus: Venus will be 55% sunlit.

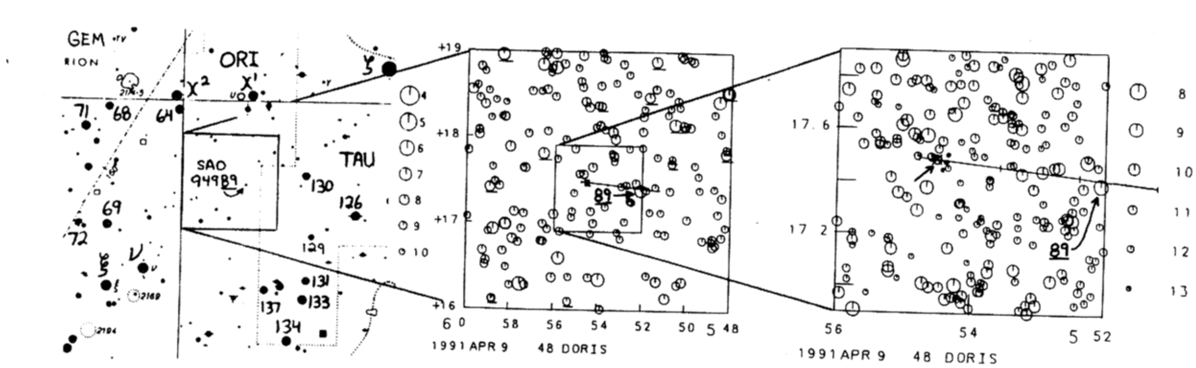
June 5: Chiron's large distance makes the path location very uncertain. Chiron is probably a giant comet, since it now has a coma.

June 10: The star is ZC 3281.

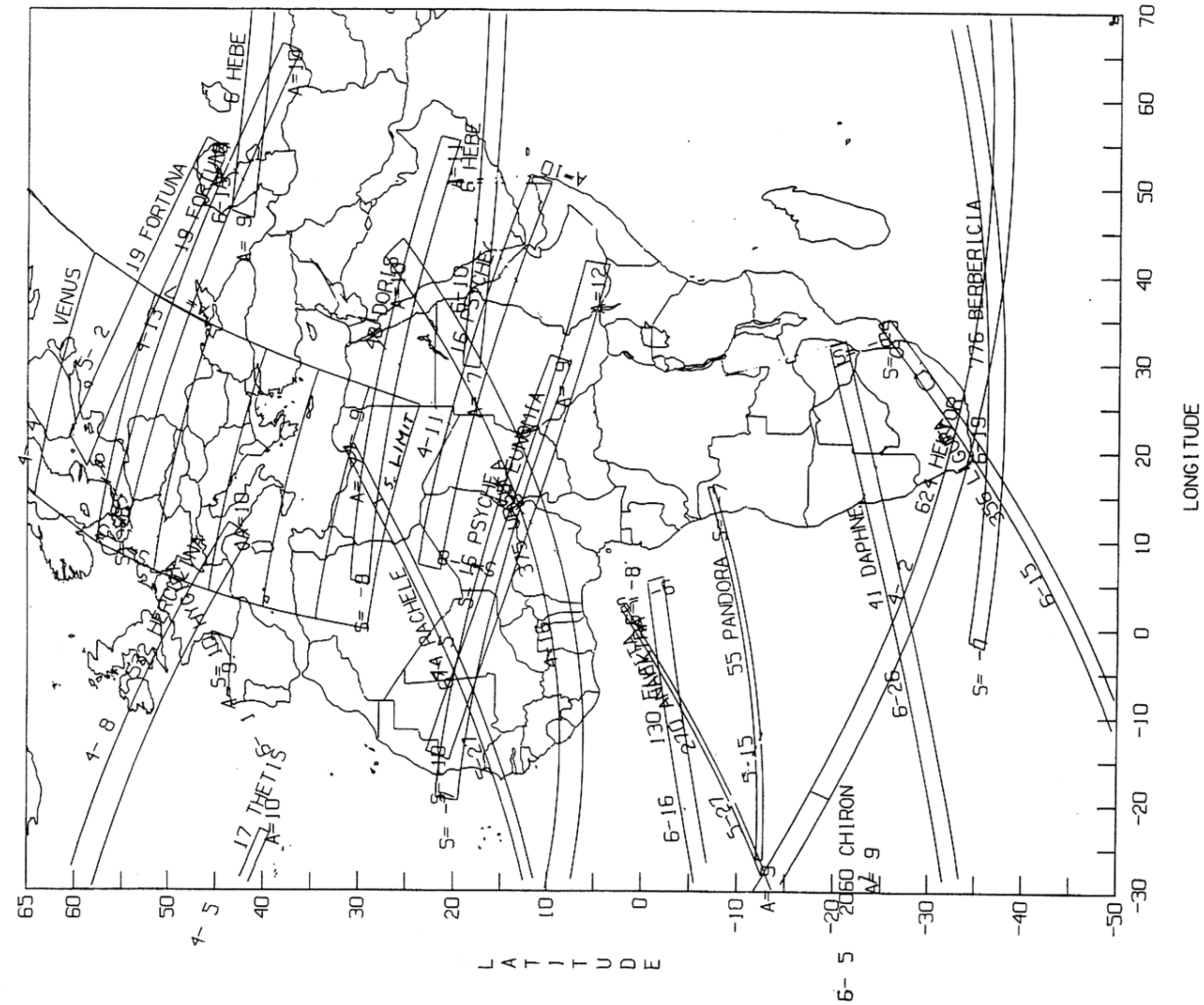
PLANETARY OCCULTATIONS. 1991 APR. - JUNE

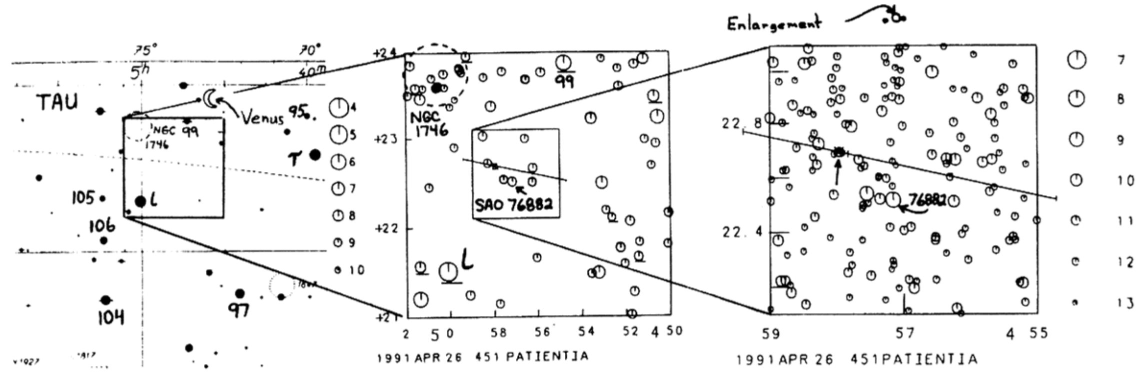


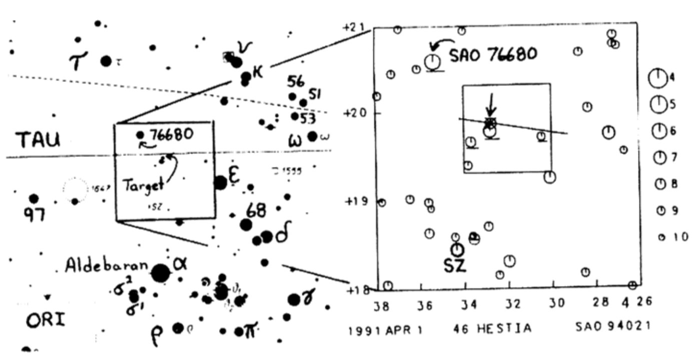


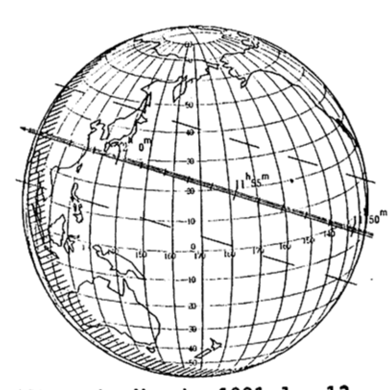


PLANETARY OCCULTATIONS. 1991 APR. - JUNE

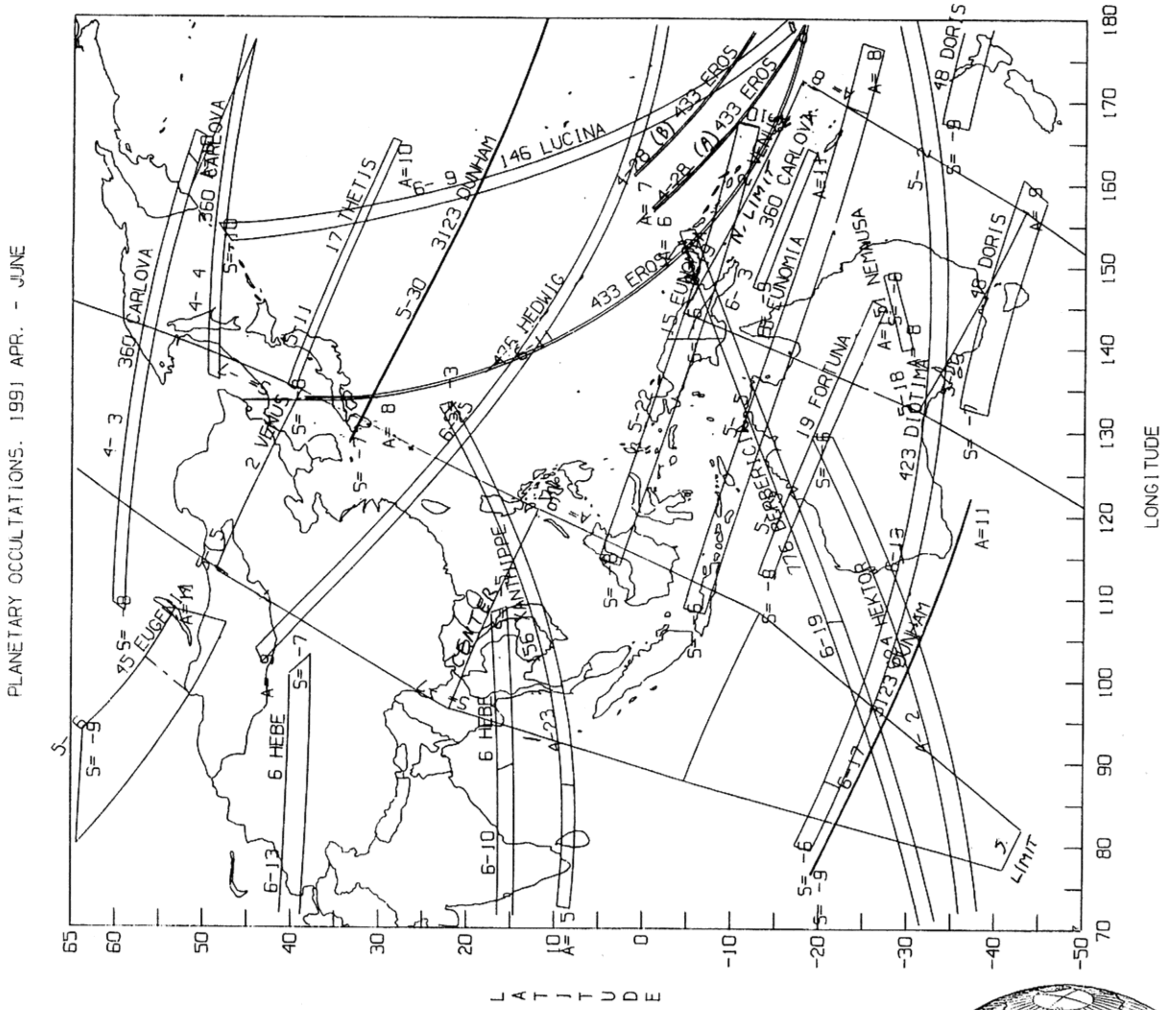


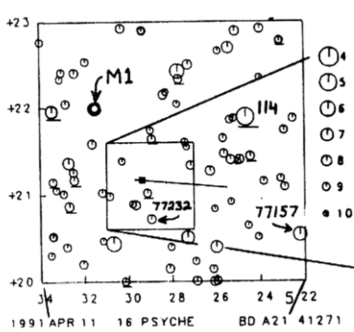


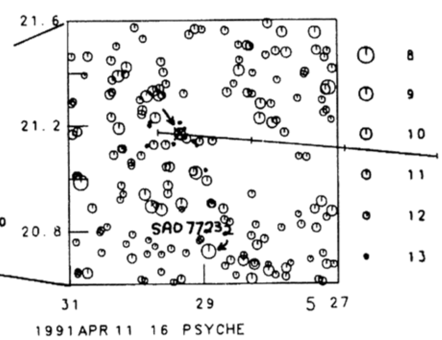




Alhena by Myrrha 1991 Jan 13







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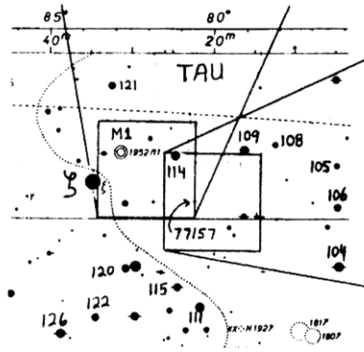
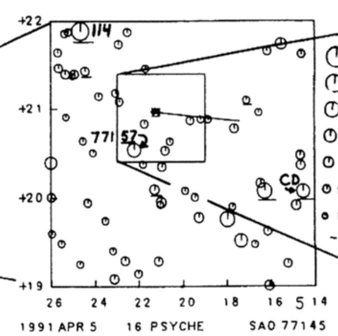
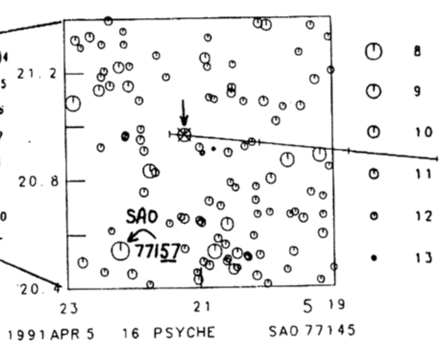






June 11, Jupiter: Only the northernmost part of Jupiter will cover the star, so the actual event will be shorter than the listed central duration.

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.

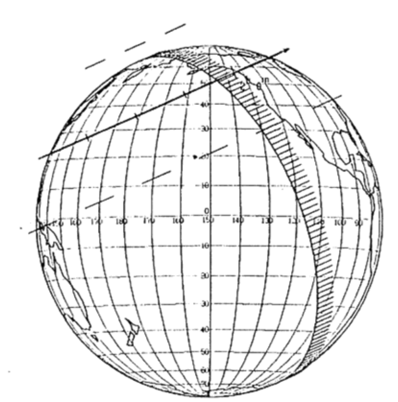
Welcome addresses were given by Mr. Beuchle, Dr. Otto, Mr. Bode, and David Dunham. A major item of discussion at the meeting was the reduction of occultation times, especially with MS-DOS PC-compatible software, some of which was demonstrated at the meeting. It was decided that local, national, and regional 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	P L A N E T		S T A R D	Stellar Diameter			
Date	No.	Name	SAO/DM No	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 duplicitly 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).
$: 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, SEP3, 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 (1980), 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.

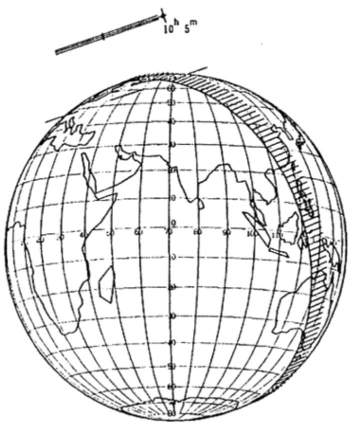
Notes for individual SAO stars are given below:

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.



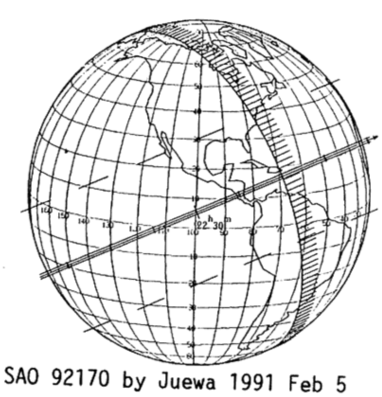
SAO 146465 by Nemausa 91 Jan 23
= ZC 3383 = 82 Aquarii

Anonymous by Herculina 91 Jan 26

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	84Feb11	Evans
093803	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	78Mav16	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
158804-	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	Radick
161255	P	K	8.0	8.6	.08	280	78Apr27	Radick
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
165339	P	K	8.5	11.3	.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

Anonymous by Hestia 1991 Feb 2

Anonymous and Hermione 1991 Feb 3

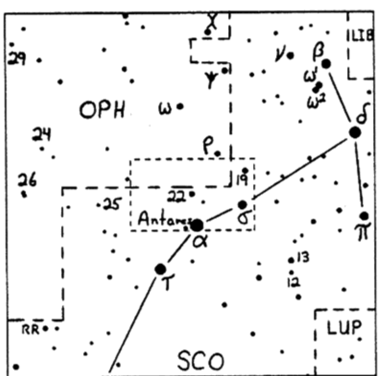


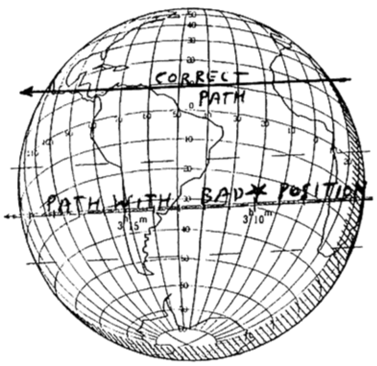
SAO 92170 by Juewa 1991 Feb 5

674 Rachele – SAO 184425

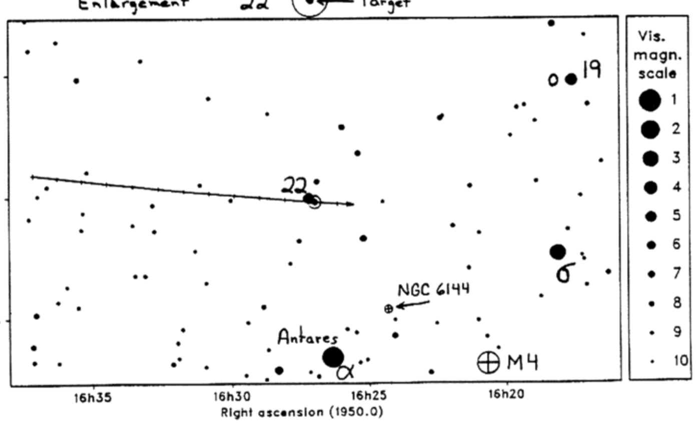
1991 may 27 3h13.2m U.T.

Minor planet :			Star :	Source cat. Yale
V. mag. = 12.13	Diam. = 95.9 km = 0.06"		α = 16h26m56.676s	δ = −25°02'~~19.44"~~ 22.02
μ = 32.15"/h	π = 3.71"	Ref. = MPC 4377	V. mag. = 7.32	Ph. mag. = 7.58
Δm = 4.8	Max. dur. = 6.2 s		Sun : 174°	Moon : 19° , 98%



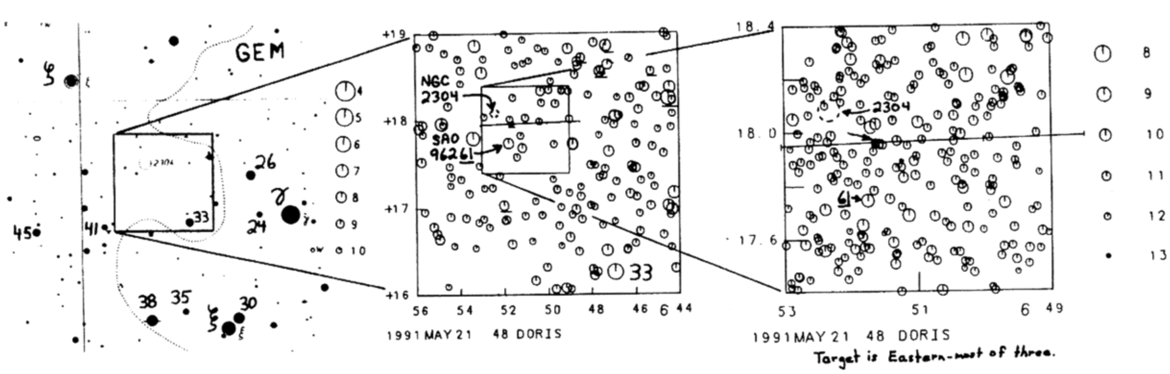


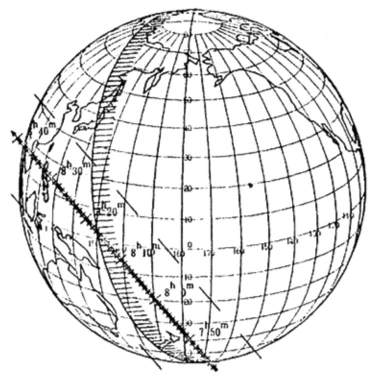
Enlargement 22 Target



L 1 954 by Herculina 1991 Jan 19

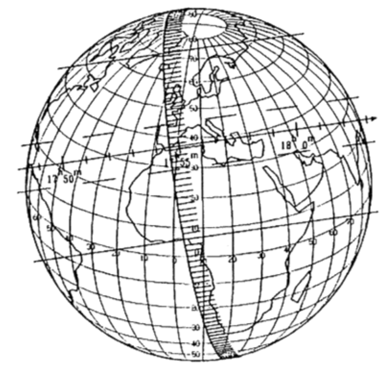
SAO 115296 by Kleopatra 91 Jan 19



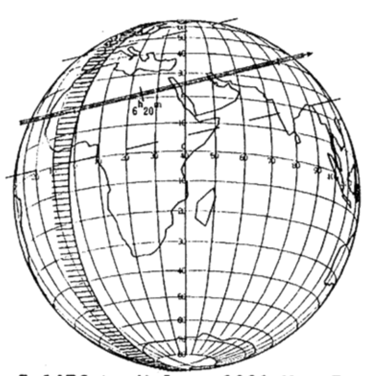


A21°43855 by Thetis 1991 Feb 10

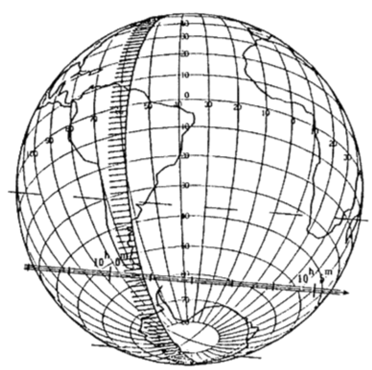
L 1 4701 by Eunike 1991 Feb 20



SAO 76660 by Mars 1991 Feb 21



L 5 1476 by Melete 1991 Mar 5

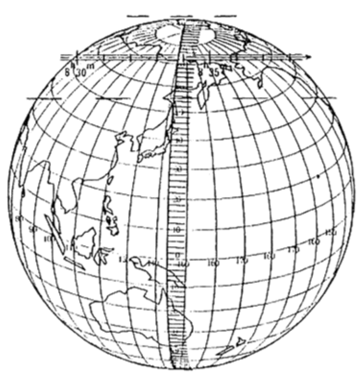


SAO 210241 by Ligura 1991 Mar 6

SAO 137817 by Pallas 1991 Mar 7

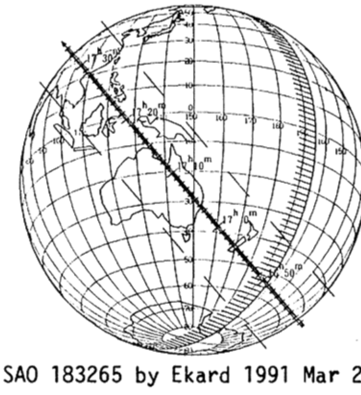
BD +26° 2149 by Aeria 91 Mar 16

Anonymous by Davida 1991 Mar 17

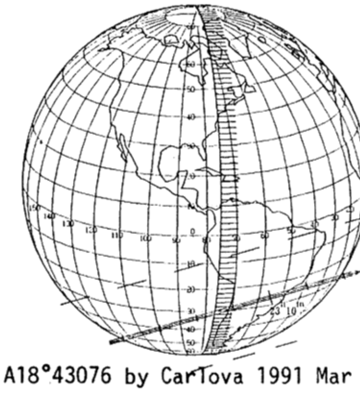


L 1 106 by Fortuna 1991 Mar 18

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:

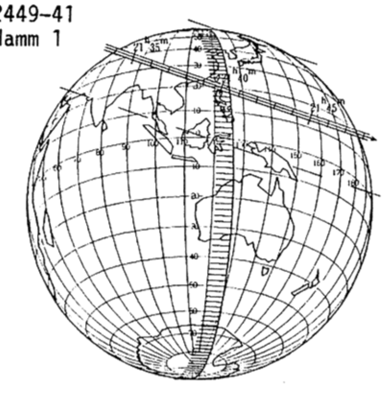
President	David W. Dunham
Executive Vice President	Paul Maley
Executive Secretary	Gary Nealis
Secretary-Treasurer	Craig and Terri McManus
VP for Grazing Occultation Services	Joe Senne
VP for Planetary Occ'n Services	Joseph Carroll
VP for Lunar Occultation Services	Walter Morgan
ON Editor	Joan Bixby Dunham
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.

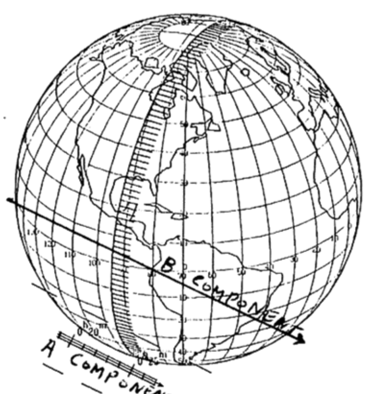
The Dunhams maintain the occultation information line at (301) 474-4945. Messages may also be left at that number.

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

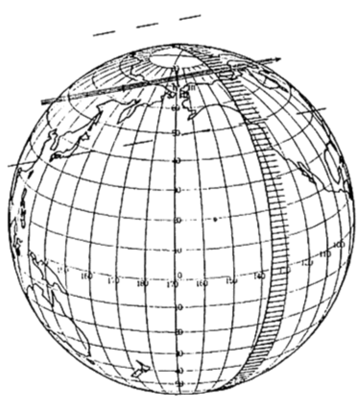
Eberhard Bredner
Astrag VHS Hamm
PO Box 2449-41
D-4700 Hamm 1
Germany



B23° 65574 by Diotima 1991 Mar 27



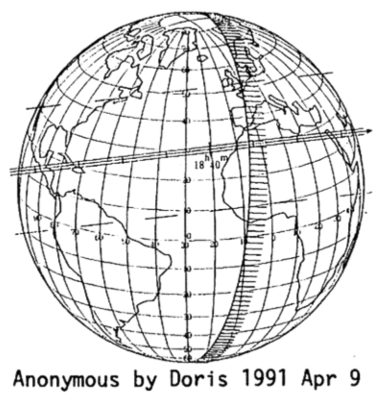
SAO 79974 by Metis 1991 Mar 28



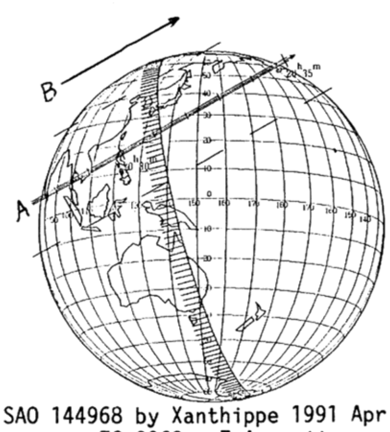
SAO 94021 by Hestia 1991 Apr 1

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